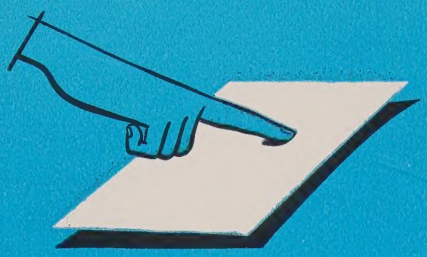
Tappi

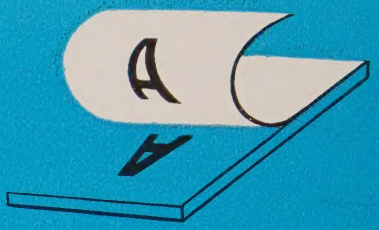
PUBLISHED BY THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY

MAY 1949

FOR SMOOTHER FINISH

FOR BETTER PRINTABILITY





IN PAPER AND PAPERBOARD THE TREND IS TO

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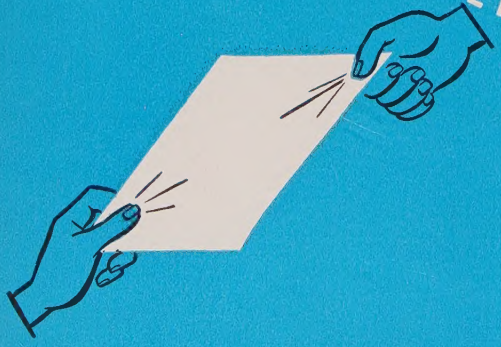

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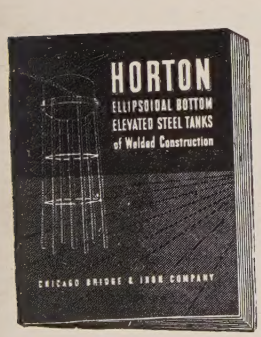
Elevated Tanks
for automatic sprinkler service

AN automatic sprinkler system will give your plant the best fire protection you can buy, provided the system is backed up by an elevated water tank. Horton welded elevated tanks provide dependable gravity water pressure for sprinkler systems at all times.

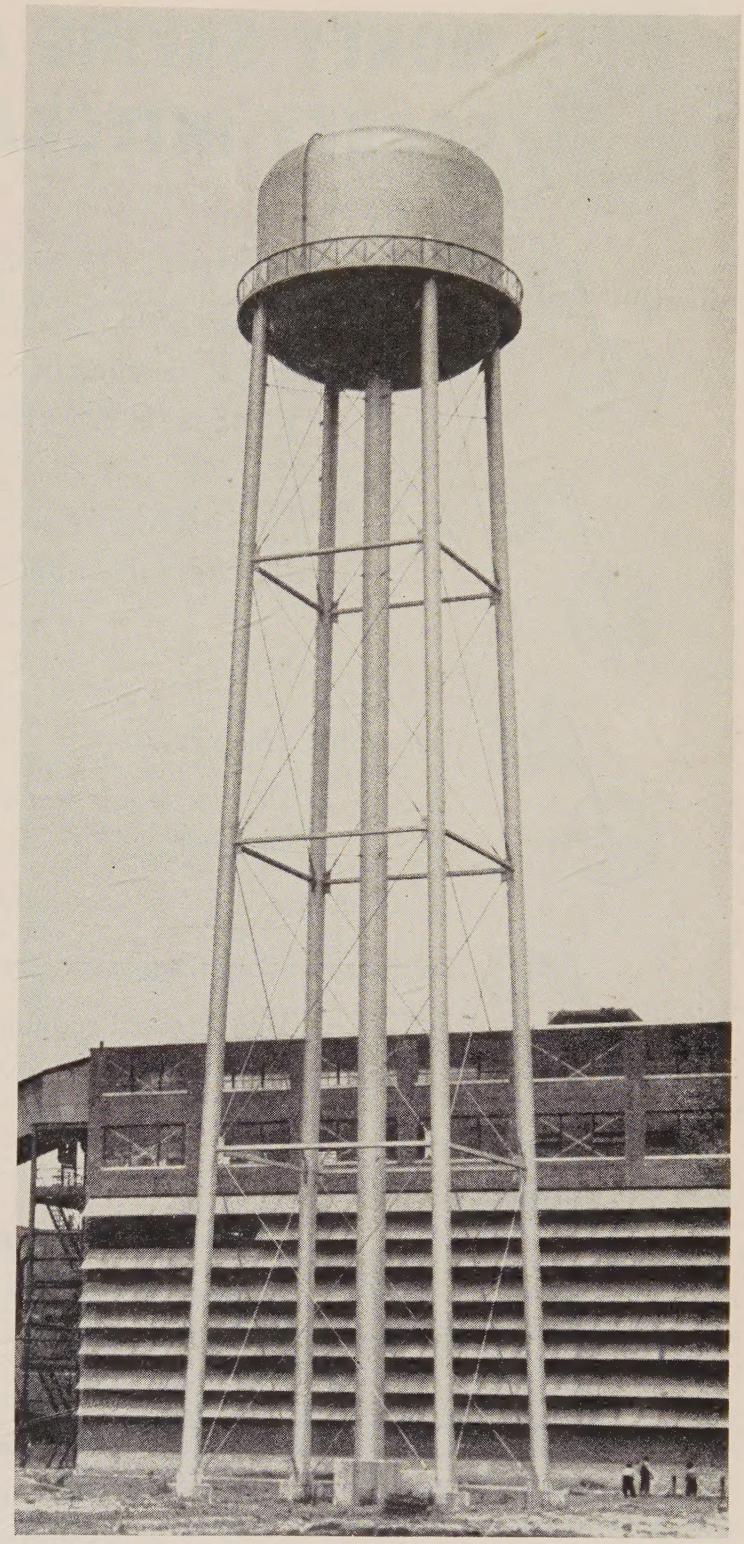
Elevated tanks can be used as the primary source of water, or as a secondary source when there is insufficient pressure in the mains to take care of the required load. In either case, you will have plenty of water available the instant a fire breaks out.

Horton ellipsoidal-bottom elevated tanks are built for use with automatic sprinkler systems in capacities from 40,000 to 500,000 gallons. They can be designed for dual service, to provide water for both general use and fire protection. When this is done, the piping connections are arranged to hold the fire protection water in reserve. If you're planning to install an elevated water tank, write our nearest office outlining your requirements.



HORTON ELEVATED TANK BULLETIN

Write for a copy of this illustrated bulletin on Horton ellipsoidal-bottom elevated steel tanks. It contains information on the use of elevated tanks for fire protection.



A 100,000-gal. Horton elevated tank erected for the new Southern Paperboard plant at Port Wentworth, Ga. It is an all-welded structure, 125 ft. to bottom, and is used to provide gravity water pressure for sprinkler service.

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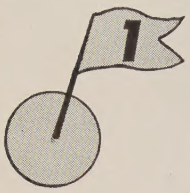

Erection time generally *one quarter* that required for other types.

Vapor body, heating element, entrainment separator and flash chamber constructed in one common shell which is set into place in one operation.

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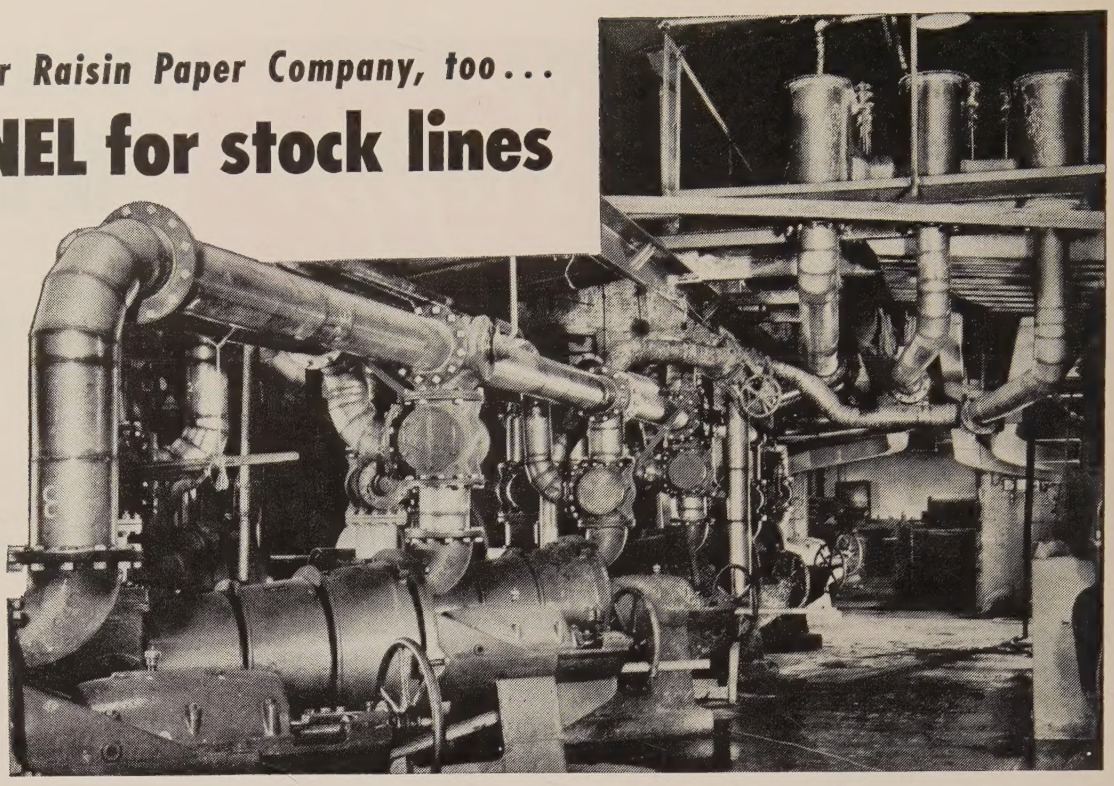
With the River Raisin Paper Company, too...

It's MONEL for stock lines



Fabricated Monel stock lines at the River Raisin Paper Company, Monroe, Michigan.

The Monel lines run from the jordan engine to the rear of a solid Monel headbox on a board machine.

• • •

WHEN leading paper mills, one after another, choose Monel* for stock lines, there must be excellent reasons for their choice.

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Stock lines of Monel last longer, cost less to maintain, and are lighter in weight.

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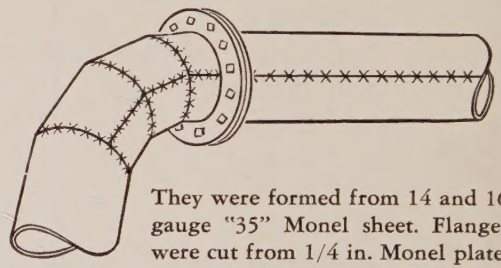
Why not investigate the money-saving possibilities of Monel stock lines for your own mill? Your nearest INCO distributor will gladly supply metal quotations and recommend experienced fabricators.

For more complete information and a list of INCO distributors, write for your copy of *"Lighter Weight, Longer Life, Lower Cost, Stock Lines."*

HOW THESE STOCK LINES WERE FABRICATED



They were formed from 14 and 16 gauge "35" Monel sheet. Flanges were cut from 1/4 in. Monel plate.

Seams, flanges, and joints were welded by argon-shielded arc.

The fabricator was Brown-Hutchinson Iron Works, Detroit, Michigan.

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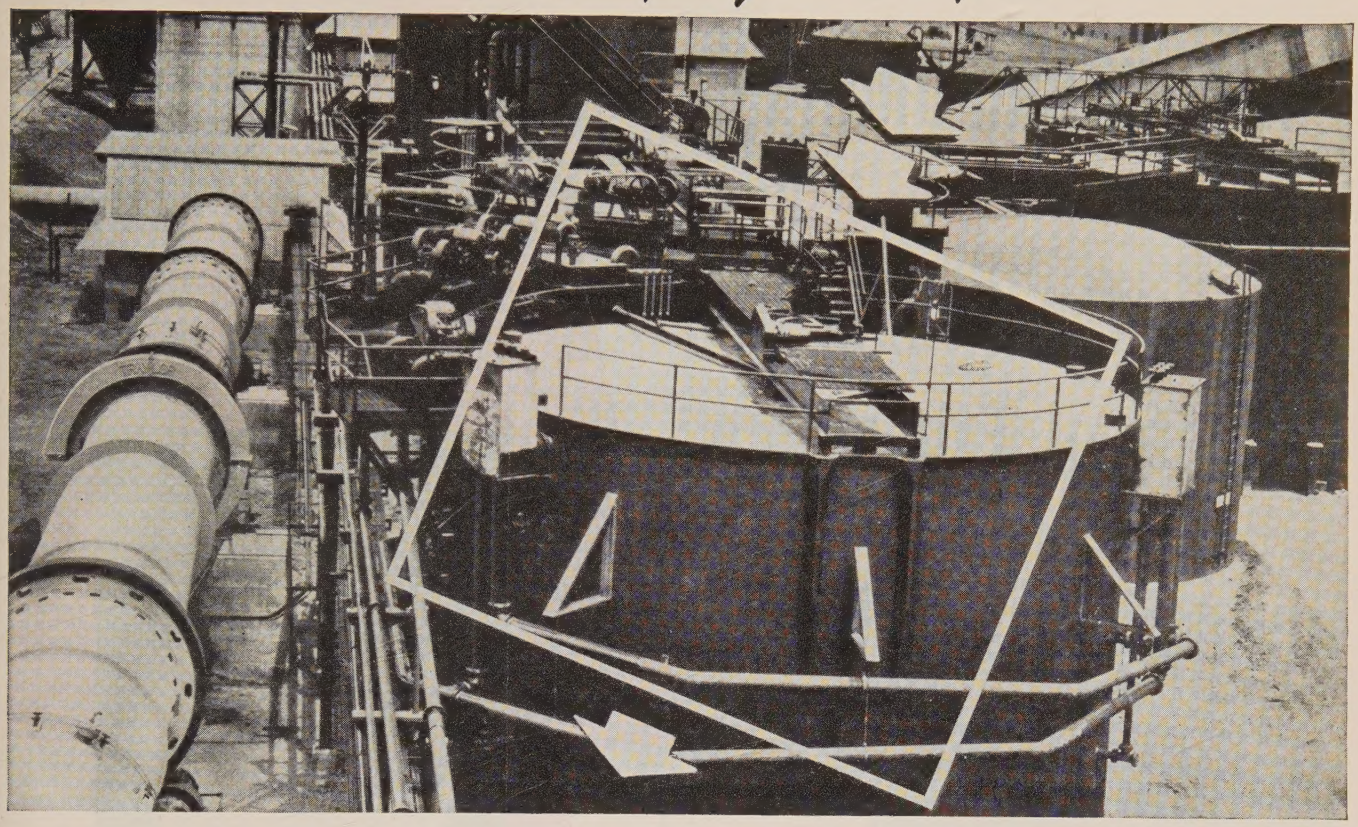

how about the **LIME MUD WASHER...**

If you now use a single-stage of lime mud washing in your recausticizing plant, you probably aren't getting the most out of your equipment. Two stages of counter-current decantation washing of lime mud prior to filtration is now a standard design feature of the Dorr Continuous Recausticizing System. There's a good chance that you can incorporate this important advance into your present system . . . at a relatively small cost . . . *without providing additional thickening area.* Modification of the feed and overflow boxes, redesign of the middle tray, and an additional diaphragm pump are the only changes required.

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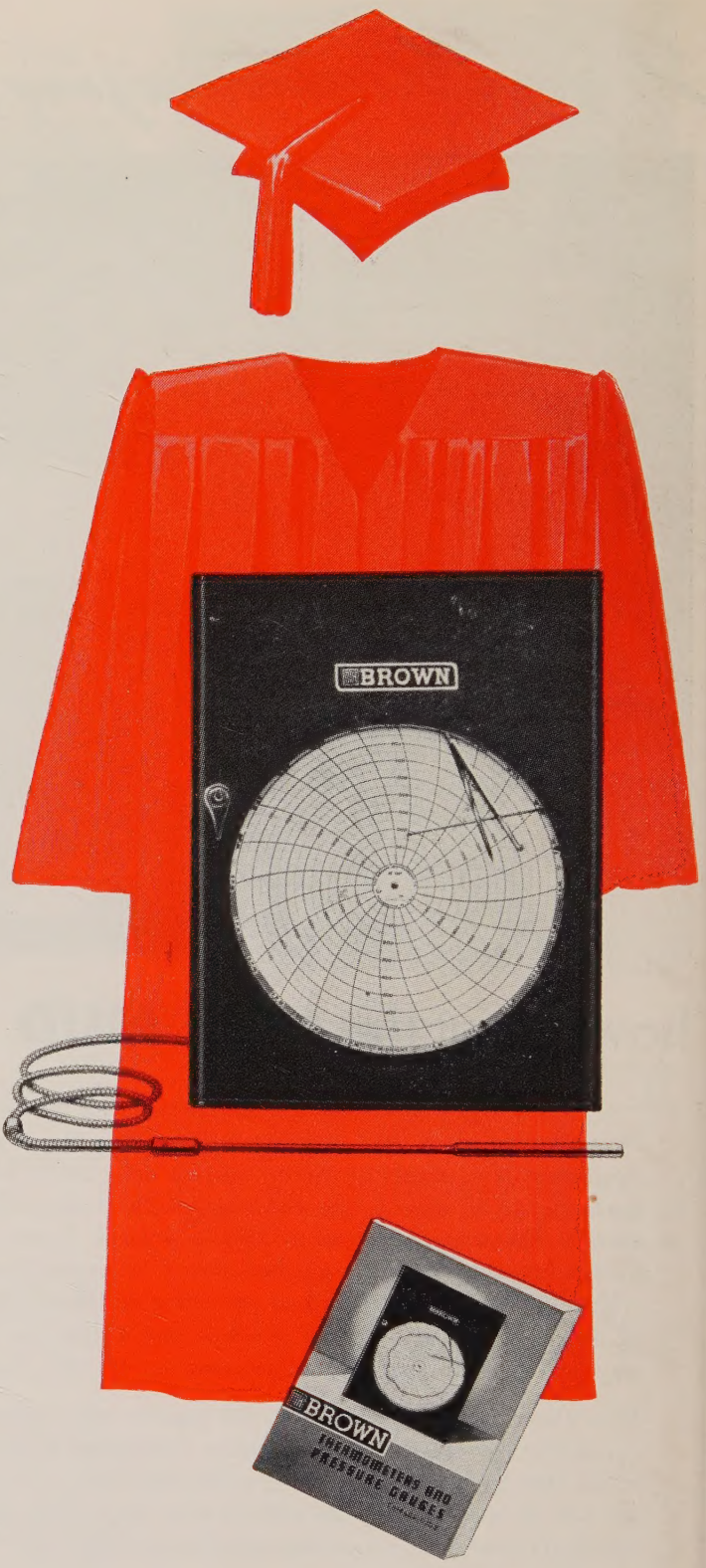

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If high cost is forcing you to sacrifice high brightness in your paper, here is a suggestion that may be of help:

Try using Celite in combination with titanium dioxide in the furnish. You'll probably find, as many mill men have, that you can get equal or better dry brightness and opacity at considerably lower cost than if TiO_2 is used alone.

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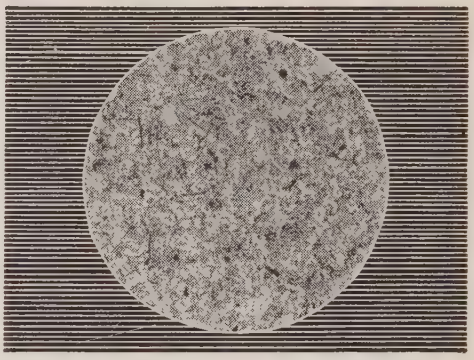
The use of small amounts of Celite in the furnish also has the desirable effect of noticeably improving the surface finish of the sheet, and, therefore, its printing qualities.



Photomicrograph of one of the high-brightness grades of Celite widely used with TiO_2 to obtain high brightness at low cost.

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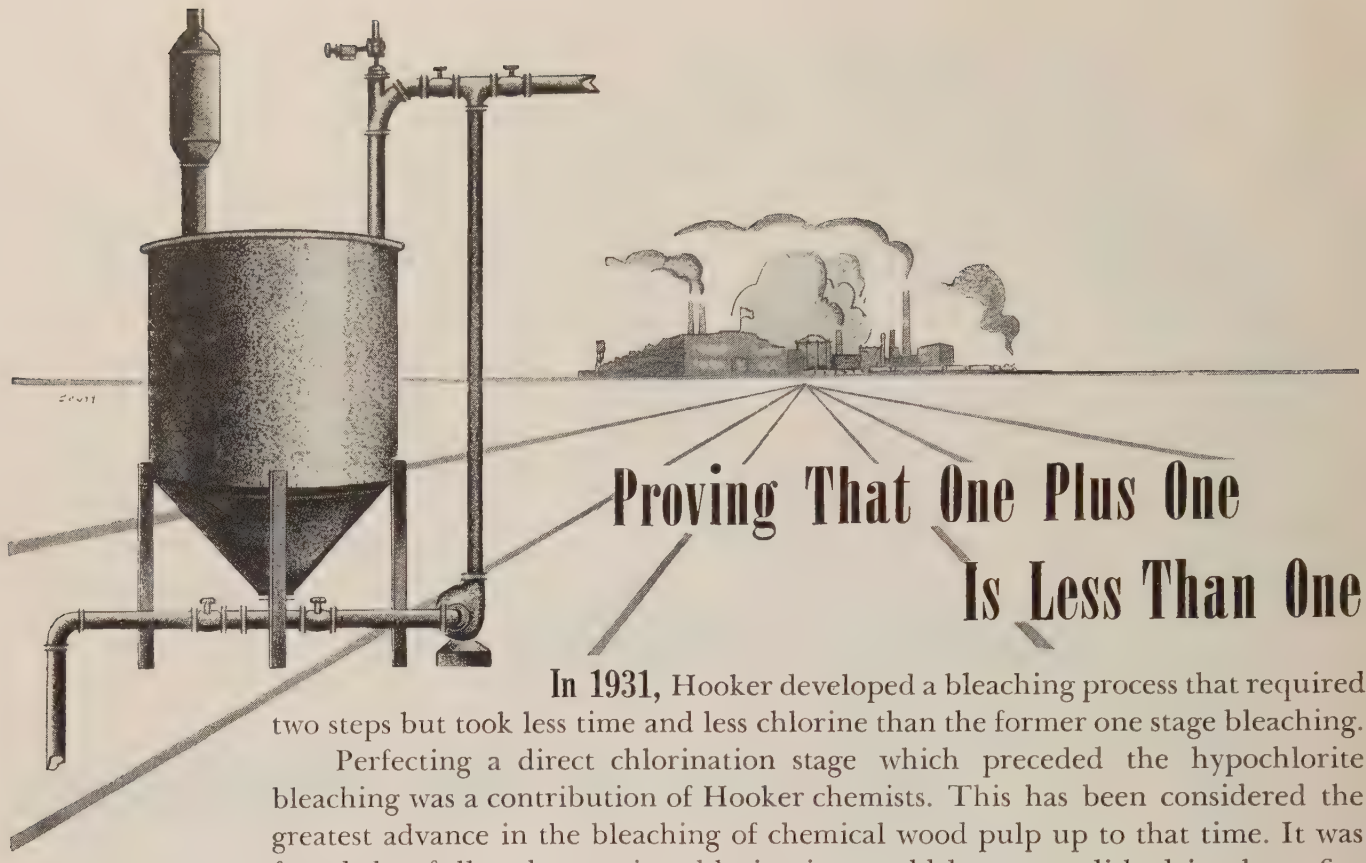

Proving That One Plus One Is Less Than One

In 1931, Hooker developed a bleaching process that required two steps but took less time and less chlorine than the former one stage bleaching.

Perfecting a direct chlorination stage which preceded the hypochlorite bleaching was a contribution of Hooker chemists. This has been considered the greatest advance in the bleaching of chemical wood pulp up to that time. It was found that full and extensive chlorination could be accomplished in about five minutes by adding an excess of chlorine at once. The unused chlorine was then utilized to make hypochlorite by the quick addition and mixing of milk of lime with the chlorinated pulp in the acid stage. For this procedure Hooker engineers designed a special screen for the milk of lime, helping make this stage more thorough and efficient.

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The work of Hooker chemists in the pulp and paper field, in the form of informative and practically helpful literature, is available upon request. Why not send for a list of these up-to-date Bulletins that may be of value to you in your work?

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B-131

Representative list of pulp and paper companies that have purchased VU Units.

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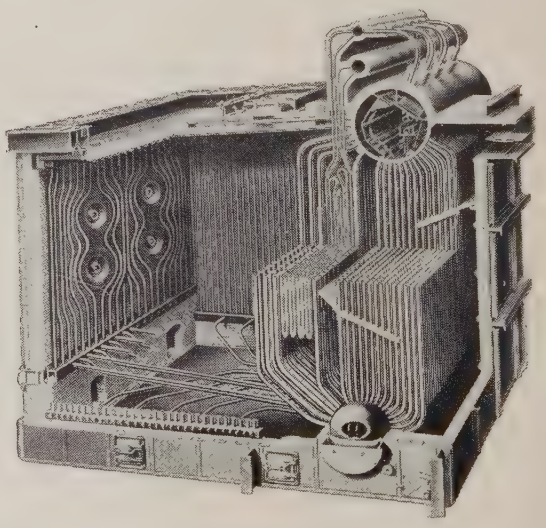

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EDITORIAL *Tappi* COMMENT

The President's Page

From time to time, in these monthly issues of *Tappi,* the President of the Association addresses himself to our Association members. Sometimes more than a page will be required to register his comments. This can be considered as presidential editorial license. In the January issue Mr. Gillespie formally introduced the new magazine and expressed hope for high association accomplishment through the leadership that it could provide.

In the April issue Mr. Bachmann used the page as a sounding board to focus attention on some of his administration objectives. It is hoped that members will read the President's page carefully because it is the wish of the President that members will react in one way or another to some of the points that are raised.

As Mr. Bachmann has said, there are new services that the Association can perform if they are wanted by the members. The only way in which the desire for these services can be made known is to respond to the suggestions made by the President. Letters may be sent to him at the Missisquoi Corporation, Sheldon Springs, Vt., or they may be addressed to the Editor of *Tappi.*

Tappi So Far

This is the fifth issue of *Tappi.* Somewhat of an editorial pattern has been set. The editorial staff wonders what you think of *Tappi,* so far. The editors read a large variety of trade and professional magazines and know what can be included between the covers of such a magazine. To date *Tappi* has limited its editorial scope to meeting papers, association news, and items of special interest to members. There are many other fields that can be covered but the question is How far should *Tappi* go in broadening its scope. The industry is served by a number of magazines, all trying to perform a service. Should any of these services be duplicated by *Tappi.* It would not be difficult to do so. What do you suggest?

Letters to Advertisers

The two preceding items were written with the intent to "draw ink." Now we find that some of our members have been writing to our advertisers and asking for information. They like to receive such letters but are interested to know which of their advertisements prompted the inquiry. Most of the letters are addressed to company and city. If the street address or box number could be included the inquiry would have added significance.

June Meetings

Since most of the members of the Technical Association have attended school during about half their lifetime they become accustomed to consider the school year to run from September to June. This same kind of thinking has, apparently for this reason, made itself felt in the scheduling of local section meetings. In a sense the section meetings are an extension of the school routines, frequently with some homework required. The June meeting, like graduation, is in most cases a special occasion. The meeting places are "out of the ordinary." This year the Empire State Section "winds up" its season at the Sagamore at Bolton Landing, N. Y., and the Maine-New Hampshire Section with many guests from the New England Section closes its season at the Wentworth-by-the-Sea, near Portsmouth, N. H. These June meetings are delightful affairs which are welcomed by the summer hotel proprietors as just the type of intensive experience needed by their staffs to prepare them to cope adequately with the more subdued and demanding rocking-chair brigade that will hold forth into Labor Day, immediately after which time the hotels are closed for the season with a three-day convention that compensates for the profitable, though otherwise dull summer season. Two national bodies, the American Pulp and Paper Mill Superintendents Association at Atlantic City, and the Technical Section of the Canadian Pulp and Paper Association at Niagara Falls, Ont., give an impetus to the summer season of their host hotels. All of these conventions are well worth attending.

The Shibley Award

Another of these summer hotel conventions, usually held in late May or June is the combined meeting of the Pacific TAPPI and Superintendents at Gearhart, Ore. (This year this meeting will not be held because of the national meeting to be held in Portland in September.) An outstanding event at this fine meeting is the banquet when the winner of the Shibley Award is announced and the prizes distributed. No graduation has ever been approached with the same degree of interest since the prospective recipients of degrees have been informed of their good fortune some time in advance. The announcement is awaited with the same interest that is displayed when one's draft number is taken out of the lottery box. The resultant feeling is, however, quite different and instead of the selection being made by chance it is made by the weighted opinion of competent judges. The award

(*continued on page 16 A*)

THE VANDERBILT LABORATORY—NORWALK, CONN.

Use the

VANDERBILT LABORATORY

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Now, more than ever before, it is important to keep production at peak efficiency. Visit our laboratory, bring your problems and let our facilities help you solve them. Here, we can show you how our materials can be used to your best advantage. We invite and appreciate your cooperation.

★

R. T. VANDERBILT CO., INC.

230 Park Avenue, New York City

EDITORIAL COMMENT

(*continued from page 14 A*)

is made to a young man who has participated in the competition sponsored by Pacific TAPPI and has presented a technical paper of high quality before his fellow members. The Pacific Section has done much for its young members in encouraging them to be Shibley Award contestants.

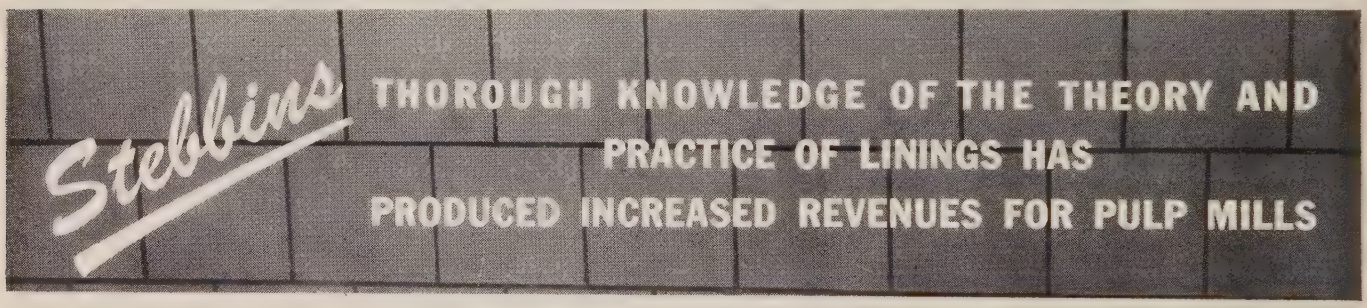
Flash!-We have just been advised that the Shibley Award presentation is to be a feature of the TAPPI Fall Meeting to be held in Portland, Ore. (September 11–15, 1949). The winning paper was presented by Mr. Vance Reynolds of The Puget Sound Pulp and Timber Company, Bellingham, Wash. This paper will again be read at the national fall meeting.

Four Thousand Tappimen

In a professional society growth, the first thousand members seem to be the most difficult to get. The Technical Association was organized in 1915 with about 200 members joining during its charter year. It was not, however, until the boom year of 1929 that it passed the one thousand mark and in 1944 it had 2128 members. As of today there are 3726 individual members and nearly 400 company members. This growth trend in organizations such as TAPPI seems to reflect the spirit of the times and is common to nearly all scientific bodies. We heard of a forest products society that started about two years ago and now has about 2000 members. One of the largest of the scientific bodies has become so big that it is unable to maintain its publishing services at the same rate as in the past. This may sound like a paradox, but it is possible to reach a publication cost that is in excess of the income from dues and advertising. At that stage the answer is not necessarily a general rate increase, particularly when it is obvious that every society wishes to serve all who care to benefit by their services. The problem has no simple solution.

Local Section Reports

An interesting feature of *Tappi* is the chapter devoted to Local Section Activities. Since *Tappi* began publication in January in the middle of the local section meeting season it has had to develop a routine of meeting reporting. Some of these reports have been quite good, especially those of the Ohio Section. However, it was not expected that such reporting jobs would be in the expert category. Like everything else the best way to learn how to do something well is to start doing it and keep doing it. When the Sections reopen their meetings in the fall it is very likely that the reporting will be greatly improved because of the experience being gained in preparing the present reports.



NEW processes and improved operation in pulp manufacture is largely dependent upon the ability of the linings of the various vessels, tanks, chests, etc., to permit of long time dependable service.

Stebbins has pioneered the linings used in the leading pulp cooking processes:

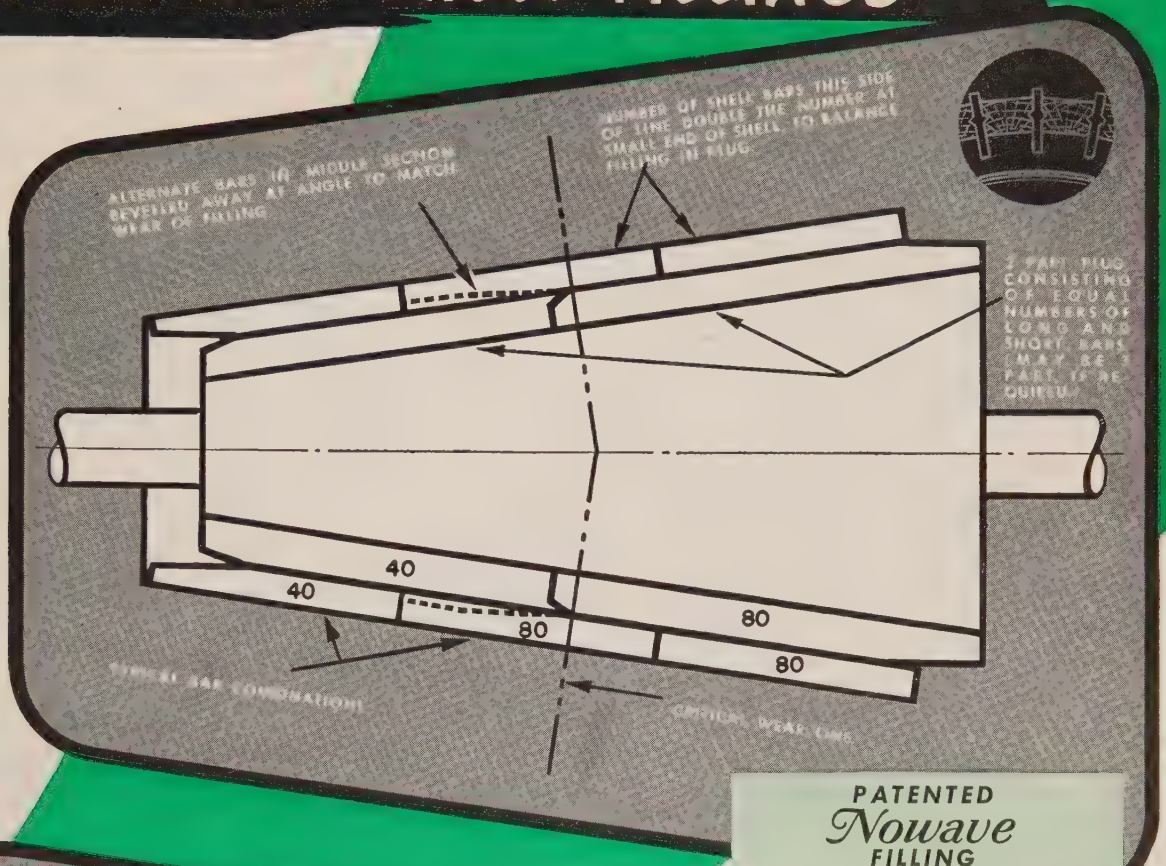
Calcium Base
Ammonium Base
Magnesium Base

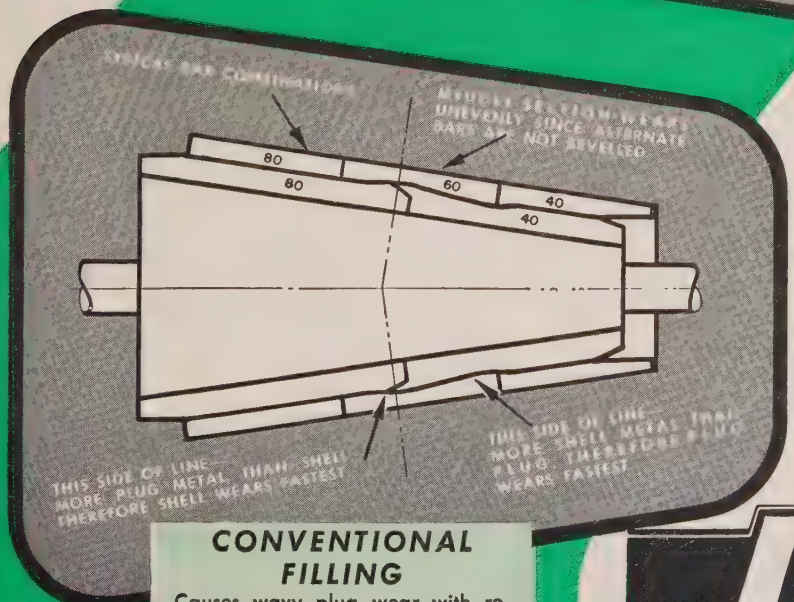
The correct lining is one of the best investments you can make when rebuilding or installing new digesters, chests, tanks, accumulators, etc., in a pulp mill. Dependable operation pays dividends year after year.

SEMCO
Stebbins Engineering and Manufacturing Company
EASTERN BOULEVARD, WATERTOWN, NEW YORK

THE JONES *Nowave* PLUG AND SHELL FILLINGS

Patented


ALTERNATE BARS IN MIDDLE SECTION BEVELED AWAY AT ANGLE TO MATCH WEAR OF FILLING
NUMBER OF SHELL BARS THIS SIDE OF LINE DOUBLE THE NUMBER AT SMALL END OF SHELL TO BALANCE FILLING IN PLUG
2 PART PLUG CONSISTING OF EQUAL NUMBERS OF LONG AND SHORT BARS (MAY BE 3 PART IF REQUIRED)
40
40
80
80
80
TYPICAL BAR COMBINATIONS
CRITICAL WEAR LINE


TYPICAL BAR COMBINATIONS
MIDDLE SECTION WEARS UNEVENLY SINCE ALTERNATE BARS ARE NOT BEVELLED
80
80
60
40
40
THIS SIDE OF LINE MORE PLUG METAL THAN SHELL THEREFORE SHELL WEARS FASTEST
THIS SIDE OF LINE MORE SHELL METAL THAN PLUG THEREFORE PLUG WEARS FASTEST

PATENTED *Nowave* FILLING

Jones Nowave Jordan Fillings provide precise plug and shell alignment. The results are:

- Closer contact throughout the life of bars.
- Straighter bar wear . . . no waves or shoulders.
- Accurate plug settings.
- Efficient stock treatment . . . better and more uniform refining.
- Longer filling life.
- Improved finished product.

The cost is nominal

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CONVENTIONAL FILLING

Causes wavy plug wear with resultant high spots and low spots in the plug and shell bars . . . an expense and waste that can be prevented by use of Jones Nowave Fillings.

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Builders of Quality Machinery for Paper Mills

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PULP AND PAPER MANUFACTURE IN THE UNITED STATES

Summary for 1948

Table I. Fibrous Materials in Pulp and Paper Manufacture: Receipts, Consumption, and Inventories by Kind of Materials, 1948 and 1947

Kind	*Receipts* 1948	*Receipts* 1947	*Consumption* 1948	*Consumption* 1947	*Inventories, Dec. 31* 1948	*Inventories, Dec. 31* 1947
	(Cords of 128 Cu. Ft.—Roughwood Basis)					
PULPWOOD, TOTAL	22,332,680	20,614,003	21,189,458	19,714,229	5,622,057	4,566,246
Domestic	20,026,284	18,529,319	.....	.....	....	....
Imported	2,306,396	2,084,684	.....	.....	....	....
Softwood, total	19,584,084	17,888,909	18,490,916	17,021,974	4,714,347	3,693,343
Domestic	17,536,855	15,990,525	.....	.....	....	....
Imported	2,047,229	1,898,384	.....	.....	....	....
Hardwood, total	2,748,596	2,725,094	2,698,542	2,692,255	907,710	872,903
Domestic	2,489,429	2,538,794	.....	.....	....	....
Imported	259,167	186,300	.....	.....	....	....
	(Tons of 2000 Pounds)					
OTHER FIBROUS MATERIALS, TOTAL	9,120,197	9,401,169	9,036,213	9,502,090[a]	1,128,699	1,087,976
Waste paper	7,605,536	7,875,959	7,584,501	8,009,052	516,620	521,019
Straw	554,059	597,464	523,611	520,706	227,539	206,685
Rags	406,886	444,807	415,668	462,388	57,752	67,048
Flax	59,108	73,080	60,969	65,940	51,749	53,129
Cotton (staple and linters)	15,238	26,031	15,932	24,970	2,623	5,266
Manila stock	13,964	10,509	13,426	10,071	2,378	1,998
All other	465,406	373,319	422,106	408,963	270,038	232,831

[a] From 1947 Census of Manufactures. All other data are from monthly surveys.

Table II. Pulpwood: Receipts, Consumption, and Inventories by Geographic Regions and by Kinds, 1948 and 1947

(Cords of 128 Cu. Ft.—Roughwood Basis)

Kind	*Total* 1948	*Total* 1947	*Softwood* 1948	*Softwood* 1947	*Hardwood* 1948	*Hardwood* 1947
RECEIPTS, TOTAL	22,332,680	20,619,259	19,584,084	17,863,868	2,748,596	2,755,391
Northeast	4,038,932	4,134,674	3,418,090	3,424,528	620,842	710,146
Appalachian	1,762,734	1,610,339	731,535	642,471	1,031,199	967,868
Lake states	3,051,933	2,913,517	2,496,361	2,377,300	555,572	536,117
South	9,997,121	8,226,525	9,456,138	7,685,265	540,983	541,260
Pacific northwest	3,481,960	3,734,304	3,481,960	3,734,304	....	....
Imported pulpwood, total	2,306,396	2,076,355	2,047,229	1,860,744	259,167	215,611
Northeast	1,372,524	1,164,461	1,166,160	991,108	206,364	173,353
Appalachian	[a]	[a]	[a]	[a]	[a]	[a]
Lake states	708,304	759,000	655,501	716,742	52,803	42,258
Pacific northwest	225,568	152,894	225,568	152,894	....	....
Domestic pulpwood, total	20,026,284	18,542,904	17,536,855	16,003,124	2,489,429	2,539,780
Northeast	2,666,408	2,970,213	2,251,930	2,433,420	414,478	536,793
Appalachian	1,762,734	1,610,339	731,535	642,471	1,031,199	967,868
Lake states	2,343,629	2,154,417	1,840,860	1,660,558	502,769	493,859
South	9,997,121	8,226,525	9,456,138	7,685,265	540,983	541,260
Pacific northwest	3,256,392	3,581,410	3,256,392	3,581,410	....	....
CONSUMPTION, TOTAL	21,189,458	19,714,229	18,490,916	17,027,522	2,698,542	2,686,707
Northeast	3,814,562	3,729,401	3,212,304	3,133,608	602,258	605,793
Appalachian	1,766,877	1,684,268	727,979	693,756	1,038,898	990,512
Lake states	2,821,496	2,724,008	2,296,931	2,199,745	524,565	524,263
South	9,442,672	8,395,117	8,909,851	7,828,978	532,821	566,139
Pacific northwest	3,343,851	3,171,435	3,343,851	3,171,435	....	....
INVENTORIES, TOTAL	5,622,057	4,566,246	4,714,347	3,693,343	907,710	872,903
Northeast	1,644,082	1,441,658	1,376,617	1,192,761	267,465	248,897
Appalachian	396,562	372,354	156,027	119,943	240,535	252,411
Lake states	1,674,430	1,486,970	1,317,051	1,150,471	357,379	336,499
South	828,074	290,957	785,743	255,861	42,331	35,096
Pacific northwest	1,078,909	974,307	1,078,909	974,307	....	....

[a] Included in data for Northeast.

In this report, prepared by Bureau of the Census, Industry Division, Paper and Printing Unit, a summary of the 1948 monthly reports on pulp, paper, and board is presented. The usual monthly order and arrangement of tables is followed.

All corrections are incorporated in these tables and estimates have been prepared to cover the few manufacturers who do not report monthly. The over-all percentage of estimate is 2%.

Receipts of wood pulp by kinds and sources, presented in

(*continued on page 20 A*)

Holding steady....

The Bettmann Archive

It wasn't always easy to hold steady in the early days of photography—
or in the pioneering of any new industry.

Niagara Alkali Company, a pioneer in the field of electro-chemistry in America has always held steady in the development of high-quality products. And, through the years, Niagara has always kept its aims in proper focus and has always had the courage and willingness to try new methods and techniques in manufacture and servicing.

Count on Niagara for Caustic Soda, Caustic Potash, Carbonate of Potash, EBG Liquid Chlorine, Paradichlorobenzene and Niagathal (Tetrachloro Phthalic Anhydride).

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LIQUID CHLORINE • CAUSTIC POTASH • CARBONATE OF POTASH • PARADICHLOROBENZENE • CAUSTIC SODA • NIAGATHAL (TETRACHLORO PHTHALIC ANHYDRIDE)

(*continued from page 18 A*)

Table VII, have been adjusted to correspond with shipments of wood pulp from domestic pulp mills and with imports of wood pulp from foreign sources. This adjustment was necessary because of misclassification of sources in numerous consumer reports.

Wherever possible the statistics for 1947 are taken from the Census of Manufactures. An exception has been made in the case of pulpwood consumption because pulpwood was reported in the Census of Manufactures in the condition in which it is received at the mill. The monthly reports on pulpwood are on a roughwood basis.

Table III. Wood Pulp, Paper and Board: Base and Actual Production by Major Grades, 1948 and 1947

(Tons of 2000 Pounds)

Item	1948			1947		
	Production base, Dec. 31	*Production*	*Per cent of base*	*Maximum annual capacity, Dec. 31*	*Production*	*Per cent of capacity*
WOOD PULP, ALL GRADES, TOTAL	14,627,574	12,872,292	88.0	13,134,996	11,945,864	90.9
Sulphite	3,169,712	2,811,216	88.7	2,955,080	2,795,962	94.6
Sulphate	6,808,723	6,013,696	88.3	5,836,464	5,356,710	91.8
Soda	557,623	509,864	91.4	525,940	491,580	93.5
Groundwood	2,603,070	2,175,107	83.6	2,450,121	2,049,814	83.6
All other	1,488,446	1,362,409	91.5	1,367,391	1,251,798	91.5
PAPER AND BOARD, ALL GRADES, TOTAL	24,592,636	22,048,766	89.6	22,875,557	21,101,833	92.2
Paper	12,025,126	11,194,860	93.1	11,530,355	10,692,851	92.7
Paperboard	10,968,970	9,440,668	86.1	9,942,207	9,186,810	92.4
Wet machine board	160,787	139,803	86.9	167,680	149,800	89.3
Building board	1,437,753	1,273,435	88.6	1,233,315	1,072,372	86.9

Production base is the sum of the daily production averages, projected to an annual basis, for any three months in which each mill reported its highest daily output record. Maximum annual capacity is the sum of mill reports from the 1947 Census of Manufacturers. As of Dec. 31, 1947, annual production base exceeded annual capacity in wood pulp by 37,000 tons, and in paper and board by 331,000 tons.

Table IV. Wood Pulp: Production, Consumption, and Inventories by Grades, 1948 and 1947

(Tons of 2000 Pounds)

Grade of pulp	Production		Consumption in paper and board manufacture		Inventories, Dec. 31			
					At pulp mills		At paper and board mills	
	1948	*1947*[a]	*1948*	*1947*[a]	*1948*	*1947*	*1948*	*1947*
ALL GRADES, TOTAL	12,872,292	11,945,864	14,374,586	13,285,435	103,049	100,258	608,269	609,695
Sulphite, total	2,811,216	2,795,962	3,332,928	3,229,339	38,843	55,262	331,233	313,737
Bleached, total	1,909,402	1,901,945	1,855,881	1,792,091	22,140	37,191	134,824	125,887
Softwood, total	1,790,946	.....	1,763,085	.....			131,091	121,719
Paper grades	1,434,246	.....	1,763,085	.....	22,140	37,191	130,915	121,534
Dissolving grades	356,700	.....		.....			176	185
Hardwood	118,456	.....	92,796	.....			3,733	4,168
Unbleached	901,814	894,017	1,477,047	1,437,248	16,703	18,071	196,409	187,850
Sulphate, total	6,013,696	5,356,710	6,663,312	5,860,288	24,573	15,884	201,181	227,809
Bleached	1,040,055	908,911	1,305,283	1,067,858	8,599	4,365	58,141	60,955
Semibleached	224,751	193,156	251,465	198,857	2,047	1,370	5,390	5,658
Unbleached	4,748,890	4,254,643	5,106,564	4,593,573	13,927	10,149	137,650	161,196
Soda	509,864	491,580	521,278	519,651	2,817	2,891	21,440	18,739
Groundwood	2,175,107	2,049,814	2,481,894	2,361 110	27,953	21,619	47,296	40,937
Defibrated, exploded, etc.	744,671	693,282	741,533					
Screenings, damaged, etc.	139,877	114,483	148,541	1,315,047	8,863	4,602	7,119	8,473
Semichemical and all other	477,861	444,033	485,100					

[a] 1947 production and consumption data are from the Census of Manufactures. All other data are from the monthly reports.

Table V. Wood Pulp Supply: Production, Transfers, Shipments, and Producers' Inventories by Grades, 1948

(Tons of 2000 Pounds)

Grade of pulp	Production	Transfers to own use	Domestic shipments to Paper and board manufacturers	Domestic shipments to All other consumers	Export shipments	Inventories, Dec. 31 Total	Inventories, Dec. 31 For own use	Inventories, Dec. 31 For later sale
ALL GRADES, TOTAL	12,872,292	11,348,898	1,023,849	404,920	93,214	103,049	76,798	26,251
Sulphite, total	2,811,216	1,727,443	641,765			38,843	22,025	16,818
Bleached	1,909,402	1,054,967	463,541			22,140	9,523	12,617
Unbleached	901,814	672,476	178,224			16,703	12,502	4,201
Sulphate, total	6,013,696	5,790,524	198,558			24,573	19,834	4,739
Bleached	1,040,055	965,984	65,554	[a]	[a]	8,599	8,599	...
Semibleached	224,751	219,654	4,104			2,047	2,047	...
Unbleached	4,748,890	4,604,886	128,900			13,927	9,188	4,739
Soda	509,864	438,439	69,722			2,817	2,613	204
Groundwood	2,175,107	2,084,679	64,480			27,953	27,828	125
All other	1,362,409	1,307,813	49,324			8,863	4,498	6,534

[a] Grade data withheld to avoid disclosure of individual operations.

(*continued on page 22 A*)

WOOD PULP

Quality Brands for all grades of Paper and Board

CELLULOSE SALES COMPANY

INCORPORATED

250 PARK AVENUE, NEW YORK 17, N. Y.

TELEPHONE: PLAZA 5-4080

(*continued from page 20 A*)

Table VI. Wood Pulp in Paper and Board Manufacture: Receipts, Consumption and Consumers' Inventories by Grades, 1948

(Tons of 2000 Pounds)

Grade of pulp	Receipts			Consumption			Inventories, Dec. 31		
	Total	Own manufacture	Purchased	Total	Own manufacture	Purchased	Total	Own manufacture	Purchased
ALL GRADES, TOTAL	14,394,092	11,795,049	2,599,043	14,374,586	11,760,461	2,614,125	608,269	88,788	519,481
Sulphite, total	3,372,793	1,900,025	1,472,768	3,332,928	1,879,196	1,453,732	331,233	33,831	297,402
Bleached	1,872,910	1,145,412	727,498	1,855,881	1,145,321	710,560	134,824	7,472	127,352
Unbleached	1,499,883	754,613	745,270	1,477,047	733,875	743,172	196,409	26,359	170,050
Sulphate, total	6,663,949	5,949,809	714,140	6,663,312	5,943,135	720,177	210,181	43,621	157,560
Bleached	1,308,318	1,061,165	247,153	1,305,283	1,058,710	246,573	58,141	19,459	38,682
Semibleached	251,763	233,922	17,841	251,465	233,909	17,556	5,390	1,207	4,183
Unbleached	5,103,868	4,654,722	449,146	5,106,564	4,650,516	456,048	137,650	22,955	114,695
Soda	524,929	440,958	83,971	521,278	440,069	81,209	21,440	4,070	17,370
Groundwood	2,458,609	2,186,263	272,346	2,481,894	2,182,156	299,738	47,296	4,908	42,388
All other	1,373,812	1,317,994	55,818	1,375,174	1,315,905	59,269	7,119	2,358	4,761

Table VII. Wood Pulp: Receipts at Paper and Board Mills by Grades, 1948

(Tons of 2000 Pounds)

Grade of pulp	Total	Domestic			Imported			
		Total	Own manufacture	Purchased	Total	From North America: Own manufacture	From North America: Purchased	All other
ALL GRADES, TOTAL	14,394,092	12,410,034	11,356,997	1,053,037	1,984,058	438,052	951,609	594,397
Sulphite, total	3,372,793	2,369,720	1,722,103	647,617	1,003,073	177,922	525,324	299,827
Bleached	1,872,910	1,521,368	1,056,411	464,957	351,542	177,922	175,283	299,827
Unbleached	1,499,883	848,352	665,692	182,660	651,531		350,041	
Sulphate, total	6,663,949	5,999,927	5,800,626	199,301	664,022	149,183	236,270	278,569
Bleached	1,308,318	1,034,030	970,100	63,930	274,288	104,163	125,555	63,839
Semibleached	251,763	224,903	220,824	4,079	26,860		7,591	
Unbleached	5,103,868	4,740,994	4,609,702	131,292	362,874	45,020	103,124	214,730
Soda	524,929	524,929	440,958	83,971[a]	....	...	[a]	...
Groundwood	2,458,609	2,155,853	2,083,862	71,991	302,756	110,947	190,015	16,001
All other	1,373,812	1,359,605	1,309,448	50,157	14,207			

Note: Receipts adjusted to correspond to supply by grade and source.
[a] Combined with domestic purchased soda pulp to avoid disclosure of individual operations in Canada.

Table VIII. Wood Pulp: Consumption and Inventories at Integrated, Partially Integrated, and Nonintegrated Paper and Board Mills, 1948

(Tons of 2000 Pounds)

Grade of pulp	Integrated mills		Partially integrated mills				Nonintegrated mills	
	Consumption Own manufacture	Inventories Own manufacture	Consumption Own manufacture	Consumption Purchased	Inventories Own manufacture	Inventories Purchased	Consumption Purchased	Inventories Purchased
ALL GRADES, TOTAL	9,927,171[a]	95,919[a,b]	1,880,979	836,798	93,605[c]	198,939	1,729,638	296,604
Sulphite, total	1,323,336	29,882	599,077	464,569	37,084	105,457	945,946	180,835
Bleached	807,434	12,981	355,701	198,537	9,438	38,226	494,209	83,702
Unbleached	515,902	16,901	243,376	266,032	27,646	67,231	451,737	97,133
Sulphate, total	5,459,606	33,180	510,861	249,025	36,541	72,123	443,820	79,171
Bleached	874,733	17,433	203,229	90,621	14,091	11,013	136,700	24,203
Semibleached	198,068	2,761	36,167	9,123	751	1,481	8,107	2,444
Unbleached	4,386,805	12,986	271,465	149,281	21,699	59,629	299,013	52,524
Soda	229,234	5,952	216,715	14,660	2,294	6,019	60,669	9,788
Groundwood	1,673,575	22,270	469,441	92,027	14,421	14,106	246,851	24,327
All other	1,241,000	4,635	84,885	16,517	3,265	1,234	32,352	2,483

[a] Includes 91,069 tons of purchased wood pulp used by integrated mills for emergency or special purposes.
[b] Includes 23,938 tons of purchased wood pulp held by integrated mills for emergency or special purposes.
[c] Includes "For own use" inventories held at affiliated pulp mills.

Table IX. Pulp, Paper and Board: Production by Mill Classes, 1948

(Tons of 2000 Pounds)

Type of Product	All classes, total	Paper mills	Paperboard mills	Wet machine board mills	Building board mills	Pulp mills only
PAPER AND BOARD, TOTAL	22,048,766	10,041,434	10,665,185	99,303	1,242,844	....
Paper	11,194,860	9,739,589[a]	1,451,895	3,376	[a]	....
Paperboard	9,440,668	227,378	9,213,290	....	....	....
Wet machine board	139,803	43,876[a]	[a]	95,927	....	....
Building board	1,273,435	30,591[a]	[a]	....	1,242,844	....
Wood pulp	12,872,292	5,479,476	4,767,273	....	1,016,122	1,609,421

[a] Combined with production in paper mills to avoid disclosure of individual operations.

(*continued on page 26 A*)

Methocel:

the Well Known Thickener

The outstanding advantage of Methocel as a thickener is that *so little will do so much.* To the paper manufacturer, this quality is highly useful in several ways.

First, Methocel's superior thickening qualities are valuable in the control of latex viscosity. Compatible with all but one commercially used latex, Methocel is the versatile thickener which gives inexpensive, uniform viscosity control.

Second, Methocel is widely used as a coating. Small quantities of Methocel will impart tack-resistant and grease-proof qualities, particularly useful for packaging of sticky or oily substances. Further, its use in gloss ink sizing and as an offset spray are well known.

Find out now about Methocel. Try it in your plant and see for yourself its many superior advantages. Send in the coupon for your *free* experimental sample of the *new* Methocel, *powdered.*

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THE new *methocel*

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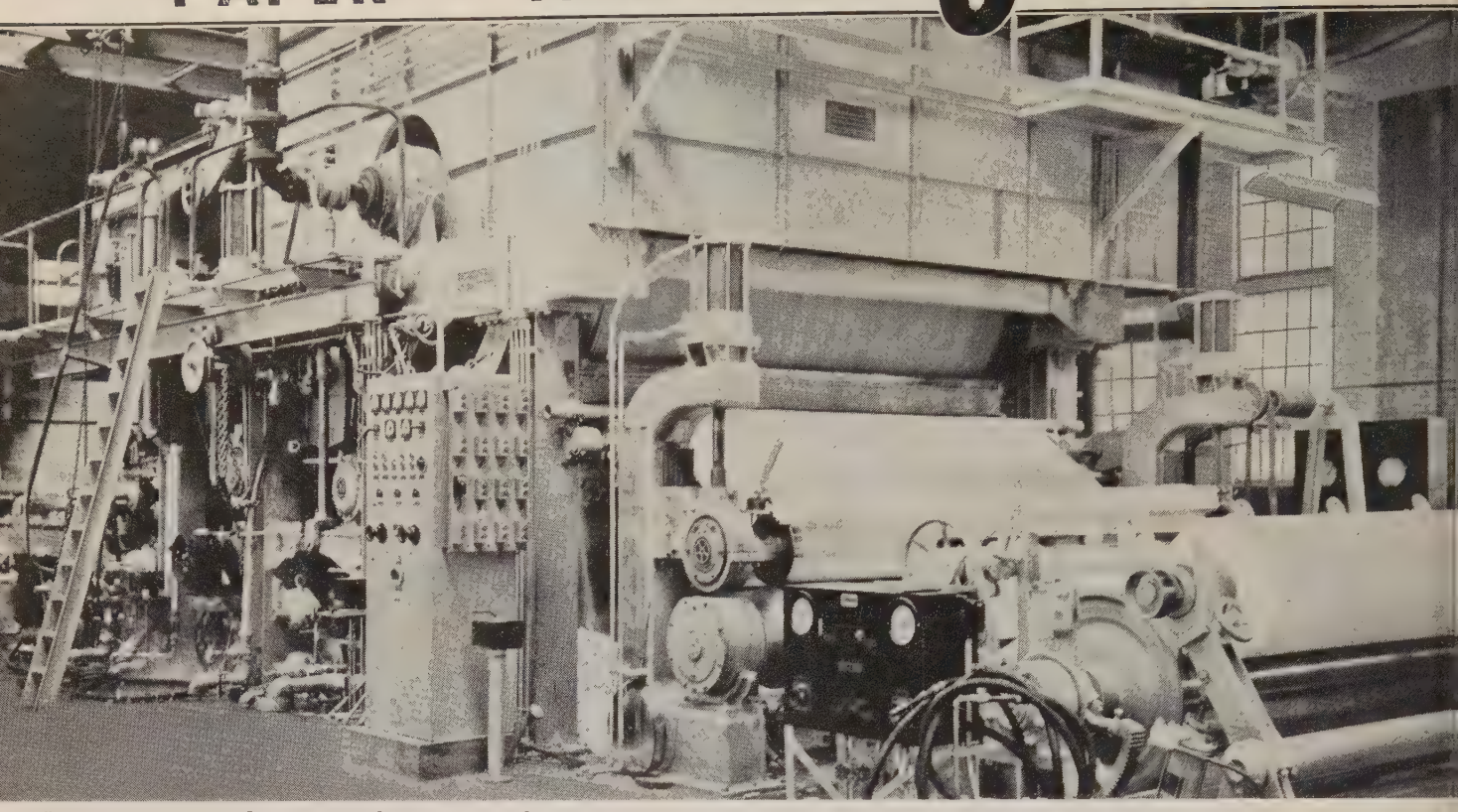

154" Puseyjones Fourdrinier Facial Tissue Machine at Groveton Papers Company, Groveton, New Hampshire. A duplicate of this machine installed at Rushmore Paper Mills, Inc., Natural Dam, New York.

GROVETON and RUSHMORE Build for the Future

Here is the latest Fourdrinier Facial Tissue Machine no in operation at Groveton Papers Company and Rushmo Paper Mills, Inc. Designed for maximum speed of 15(F. P. M. Among the outstanding features are:

(1) Flow Spreader with new closed pressure slice;

(2) Automatically controlled air loading on upper couch ro upper press roll, Yankee Dryer press roll, Calender stack, Re creping and cleaning doctors.

Whatever your papermaking problem, put it up t Puseyjones—for machines that give continuous, uniform production at high speeds.

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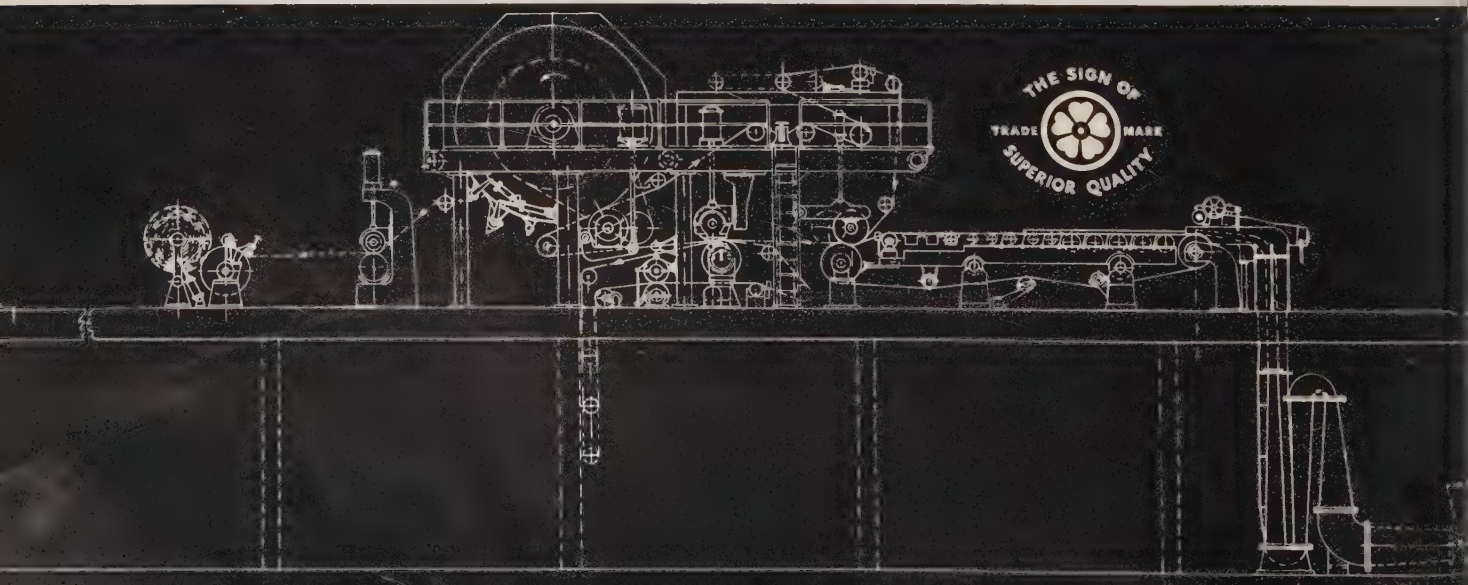
Established 1848. Builders of Paper-Making Machinery
Wilmington 99, Delaware, U.S.A.



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DRYERS* ALIKE

AS PEAS IN A POD

*

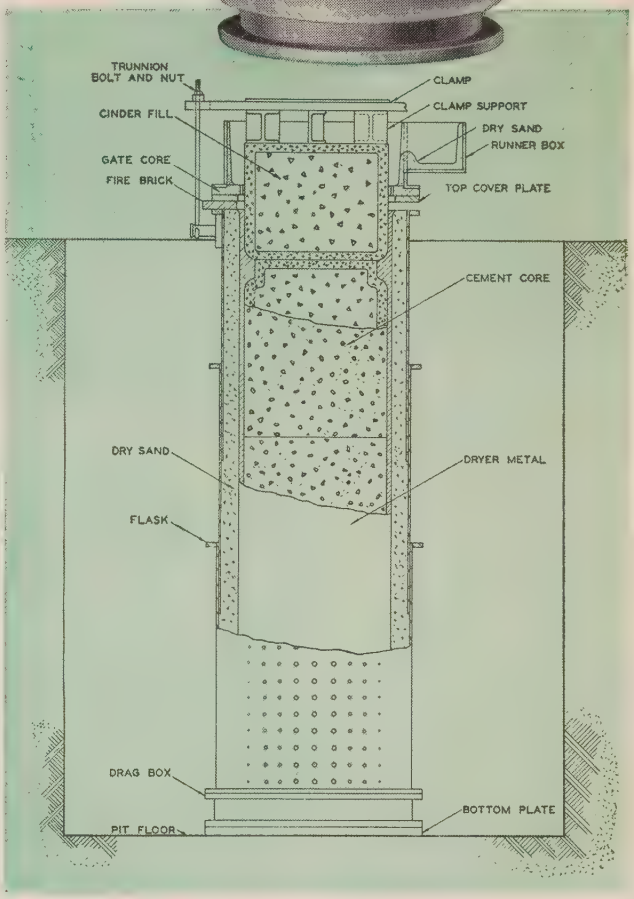
NO WEIGHTS NECESSARY FOR BALANCING

From time immemorial, it has been standard practice to use weights for balancing dryer shell castings because of the varying thickness of the shell. This was a poor expedient, a production bottleneck and made dryer uniformity well nigh impossible.

Now, a revolutionary new method (see diagram) developed by Downingtown, using a Cement Bonded Sand Core (photo upper right), enables us to PRECISION CAST duplicate dryer shells in any quantity, each having smooth inner walls and a uniform shell thickness for even drying of the sheet. Boring is not required, thus all the corrosion resistant qualities inherent in the "skin" of the cast metal are retained.

Hundreds of Downingtown "Precision Cast" Dryers are now in use, each having been made and tested under the watchful eye of an authorized inspector. They are made of Downingtown special high-nickel alloy, "Downite 150," which is an exceptionally high tensile strength iron, machines easily to a high finish, and has uniform close-grained density with inherent pressure tightness. They are available in all standard diameters for operating pressures up to 150 P.S.I. and are designed to meet the A.S.M.E. Code for Unfired Pressure Vessels.

Need a new dryer end for your machine, or additional dryers? Let Downingtown engineer it for you.



DOWNINGTOWN MANUFACTURING COMPANY

DOWNINGTOWN, PA.

DESIGNERS AND BUILDERS OF PAPER MAKING MACHINERY SINCE 1880

(continued from page 22 A)

Table X. Pulpwood, Wood Pulp, and Other Fibrous Materials: Consumption by Mill Classes, 1948

Type of product	All classes, total	Paper mills	Paperboard mills	Wet machine board mills	Building board mills	Pulp mills only
Pulpwood (cords)	21,189,458	9,249,082	7,879,808	....	1,215,939	2,844,629
Wood pulp (tons)	14,374,586	8,199,273	5,115,047	5,084	1,055,182	....
Other Fibrous Materials, Total (tons)	9,036,213	2,587,701	6,363,095	85,417	....	....
Waste paper	7,584,501	1,687,891[a]	5,839,484	57,126	[a]	....
Straw	523,611	[b]	523,611[b]	....	[b]	....
Rags	415,668	409,514	[a]	6,154	....	....
Flax	60,969	60,969	....	....	....	....
Cotton (staple and linters)	15,932	15,932	....	...	....	....
Manila stock	13,426	13,426[a]	[a]	....	....	....
Other	422,106	399,969[a]	[a]	22,137	[a]	....

[a] Combined with paper mills to avoid disclosing operations for individual companies.
[b] Combined with paperboard mills to avoid disclosing operations for individual companies.

Table XI. Paper and Board: Production by Type, 1948, 1947 and 1946

(Tons of 2000 pounds)

Type of paper	1948	1947	1946
All Types, Total	22,048,766	21,101,833	19,277,667
Paper, total	11,194,860	10,692,851	9,787,493
Newsprint	866,235	833,038	772,797
Groundwood printing and specialty paper, total	836,576	821,318	775,779
Printing	541,026	546,008	473,620
Converting	262,112	240,924	252,006
Other	33,438	34,386	50,153
Book paper, total	2,284,245	2,207,923	1,933,428
Printing	1,755,679	1,696,570	1,458,003
Converting	507,666	498,368	457,062
Other	20,900	12,985	18,363
Fine paper, total	1,156,703	1,171,539	1,145,576
Writing, total	904,141	918,349	901,670
Rag (including index)	135,588	174,110	175,514
Chemical wood pulp	768,553	744,239	726,156
Cover and text	77,611	86,801	93,352
Bristols (except rag index)	84,780	93,178	82,414
Thin	69,898	73,211	64,961
Other	20,273	...	3,179
Coarse paper, total	3,143,263	2,903,450	2,690,490
Glassine, greaseproof and vegetable parchment	128,916	156,310	158,251
Wrapping, total	816,813	667,028	763,193
Unbleached kraft	378,197	346,026	348,862
Other	438,616	321,002	414,331
Bag, total	675,053	539,864	523,633
Unbleached kraft	619,243	495,665	492,120
Other	55,810	44,199	31,513
Shipping sack	667,499	670,889	550,374
Converting, total	854,982	869,359	695,039
Unbleached kraft	497,454	598,229	...
Other	357,528	271,130	...
Special industrial	317,858	289,499	286,478
Sanitary	963,366	894,032	860,658
Tissue	230,325	194,624	183,837
Absorbent	108,614	100,486	102,811
Building paper	1,287,675	1,276,942	1,035,639
Paperboard, total	9,440,668	9,186,810	8,396,233
Liners	3,347,285	3,293,234	2,794,108
Corrugating material	1,376,076	1,370,492	1,234,340
Container chip and filler board	318,534	279,968	286,490
Folding boxboard (for use in folding box plants only)	2,153,313	2,249,136	2,317,496
Set-up boxboard (for use in set-up box plants only)	597,374	594,755	520,772
Cardboard	79,593	91,858	89,310
All other paperboard	1,568,493	1,307,367	1,153,717
Wet machine board, total	139,803	149,800	137,583
Shoe board	48,985	37,466	65,565
Binder board	45,715	70,325	55,697
Other	45,103	42,009	16,321
Building board	1,273,435	1,072,372	956,358

Note: Production in 1946 from special annual grade survey, in 1947 from Census of Manufactures, and in 1948 from monthly surveys.

United States Imports, 1948 and 1947

(Tons of 2000 pounds)

	Twelve months 1948	Twelve months 1947
Unbleached Sulphite Pulp		
Canada	455,718	439,979
Newfoundland	4,233	7,759
Sweden	155,045	223,770
Finland	66,228	60,531
Russia	..	4,928
Austria	1,496	..
Total	682,720	736,967
Bleached Sulphite Pulp		
Canada	472,780	453,014
Newfoundland	1,998	95
Sweden	46,907	46,667
Finland	24,381	27,852
Norway	12,771	6,648
Austria	200	..
Total	559,037	534,276
Unbleached Sulphate Pulp		
Canada	149,787	145,608
Sweden	113,865	202,734
Finland	72,493	115,219
Norway	111	229
Mexico	1,054	7,342
Total	337,310	471,132
Bleached Sulphate Pulp		
Canada	218,148	176,917
Sweden	65,967	62,578
Total	284,115	239,495
Groundwood Pulp		
Canada	275,562	284,232
Newfoundland	906	..
Sweden	2,558	12,073
Finland	12,798	14,263
Norway	336	2,700
Total	292,160	313,268
Pulpwood (Cords)		
Rough	916,457	936,093
Peeled	1,010,993	820,648
Rossed	806	730
Chipped	95,342	70,846
Total	2,023,598	1,828,317

SUMMARY

The production of paper and paperboard in 1948 was in excess of 22,000,000 tons as compared with a little more than 21,000,000 tons in 1947. Wood pulp production was more than 12,872,000 tons, compared with less than 12,000,000 tons in 1947. Pulp consumption of paper and paperboard mills was in excess of 14,375,000 tons compared with 13,285,435 tons in 1947. Total pulpwood receipts were 22,332,680 cords, compared with 20,619,259 in 1947.

Here Were Made America's First Paper Boxes

In 1844 American jewelers were dependent on crude, costly imported paper boxes. Aaron Dennison of Boston decided that America needed a new industry, and that his father, Colonel Andrew Dennison, cobbler, of Brunswick, Maine, was just the man to start it. To Colonel Dennison, then 58, the idea of competing single-handed with European industries was a challenge. With his old shoe knife he cut out the parts from pasteboard and glazed paper. His daughters, Julia and Matilda, joined, pasted and finished the boxes, which found a ready market. Thus were made the first set-up paper boxes produced in America and thus began the Dennison Manufacturing Company.

Today, paper boxes of every shape, size and character have become indispensable in the conduct of American business. They have played an important part in making paper the product most used by man.

For information on the first set-up boxes made in America, we are indebted to the book, "Paperboard and Paperboard Containers," by Harry J. Bettendorf. A copy of "Paper — Pacemaker of Progress," published by F. C. Huyck & Sons as a tribute to the Paper Industry, will be sent free upon request.

KENWOOD WOOL PRODUCTS
HUYCK *Felts*

F. C. HUYCK & SONS • *Kenwood Mills* • RENSSELAER, N. Y.

Nonfibrous Raw Materials Report—1948

EDWARD N. POOR

THE PRODUCTION of paper and paperboard continued at a high level during the year. This was reflected in a steady demand for chemicals, in many cases in excess of productive capacity.

CAUSTIC SODA

There has been some slight reduction in the amount of caustic soda consumed this year but this is probably somewhat seasonal and is not to be construed as a reduction of the total tonnage. It is believed that the situation in regard to supply of caustic will be somewhat eased during 1949, but in certain localities it will still be in short demand.

The only variation in quality is the increase in purity which is constantly improving. The price has increased somewhat during the past year but should remain fairly firm for the next few months.

There are no new uses for caustic in the paper field but some new uses are continuously being found in other industries. There has been an effort to substitute ammonia for caustic soda in some cooking operations but this has not proved entirely satisfactory due to the large losses which occur. Undoubtedly more work will be done on this in the future, and ammonia may replace caustic soda to some extent in the pulp field.

There has been a considerable increase in production during the last year and there will be some increase in production during the early months of 1949. The additional amount which will be produced will probably not have an appreciable effect on the demand of caustic soda.

SODA ASH

Soda ash continues in heavy demand. New production entering the field in late 1948 and in 1949 is expected to ease the market to normalcy.

The excellent quality of soda ash has been well maintained under adverse operating conditions, and it is anticipated will continue throughout 1949. The price of soda ash in bulk has increased $0.10 per hundredweight carload lots, effective July 1, 1948.

Substantial quantities of new soda ash have been used in semichemical pulping and in replacement of salt cake in the kraft industry. It is anticipated that the former use will expand materially throughout 1949. Soda ash is the most economic chemical which can be used in the soda base sulphite process. It is anticipated that a few mills will go over to the soda base in 1949.

LIME

The demand for chemical quick and hydrated lime is steady with lime manufacturers operating at full capacity.

Prices of lime have increased in all sections due to the continuous advances in the cost of coal, labor, and raw materials used in the manufacturing of chemical lime products.

Limestone burned in a rotary kiln mixed with the sludge from the kraft pulping process is replacing quick lime. A $^3/_8$ by $^1/_4$-inch clean, high calcium limestone has proved to be the most efficient size for this application.

It is difficult to predict the availability of lime over a long period. However, if the demand for paper, chemicals, and steel continues at its present level, there will be very little free lime tonnage available during 1949.

CHLORINE

Consumption of this material has increased only moderately during 1948. There has been no change in quality, and prices have advanced approximately 7% in tank cars during the current year.

New uses for liquid chlorine developed during 1948 are of no real tonnage importance; large new uses are from captive plants supplying chlorine in gas form. No important substitutes have been developed and the supply now meets the demand.

SULPHUR

The consumption of sulphur by the paper industry has been almost the same in 1948 as it was in 1947, and no new uses in the paper industry have been reported during the year.

Sulphur for the paper industry continues to be available to supply all the demand.

The price of sulphur as reported by the *Oil, Paint & Drug Reporter* has been advanced from $16 to $18 per long ton f.o.b. cars, mines.

No substitutes for sulphur have come into use during the year. An experimental operation at the Port William plant of the Abitibi Power & Paper Company using liquid sulphur dioxide recovered from smelter gases has been reported under the title: "The Use of Liquid Sulphur Dioxide for Calcium Bisulphite Acid Production." This article appeared in the Convention Issue of the *Pulp and Paper Magazine of Canada* beginning on page 215.

ROSIN

While domestic consumption of rosin has been at a good level, particularly in the paper industry, rosin has been plentiful during the past season due to increased production and to exports being smaller than expected. This resulted in some price weakness, but severe declines were prevented by a Government loan program for gum rosin producers. In fact, an increase in Government loan values in June, 1948, resulted in higher prices.

EDWARD N. POOR, Member TAPPI; Chairman, Nonfibrous Raw Materials Committee; Hudson Pulp & Paper Corp., Augusta, Me.

ST

IN ENGINEERING FOR PULP PRODUCTION

SWENSON *first* adapted Long-Tube Vertical Evaporators to black liquor.

SWENSON *first* developed the annular steam baffle.

SWENSON *first* used the liquor deflector.

SWENSON *first* developed a double-body first effect.

SWENSON was *first* to feed the last two bodies in parallel.

SWENSON was *first* to design and use internal catchalls.

SWENSON was *first* with a practical design for a successive multistage condensate flash system.

SWENSON was *first* with a practical design for a thick liquor flash system.

SWENSON was *first* with 5-body quintuple-effect evaporation.

SWENSON was *first* with 6-body quintuple-effect evaporation.

SWENSON was *first* with sextuple-effect evaporation.

SWENSON was *first* with septuple-effect evaporation.

SWENSON was *first* with the 2-pass heating element.

SWENSON was *first* with chromium-plated tubes in heating elements and surface condensers.

SWENSON *first* employed longer and longer tubes.

SWENSON was *first* to recommend the use of the sodium bisulfate method of removing calcium aluminum silicate scale.

SWENSON was *first* to suggest the use of the white-liquor method of removing fouling from the vapor side of the tubes.

SWENSON *first* provided for circulating white liquor for cleaning.

SWENSON is the *first* and *only* evaporator manufacturer to publish technical information for the benefit of the pulp mill industry.

SWENSON was *first* in the successful commercial application of 2-stage washing on a single drum.

Swenson has co-operated closely with pulp mill engineers for more than 60 years. Through intimate knowledge of their operating problems, Swenson has pioneered a long succession of engineering advances in pulp manufacturing processes and pulp mill equipment.

The tabulation of Swenson ***firsts*** (shown at left) indicates how Swenson customers consistently have been provided with outstanding developments leading to greater operating efficiency and economy.

Swenson is still pioneering! Process equipment development is a continuing Swenson program which enables us to incorporate in each unit of equipment the benefits of the latest research and practical technological progress.

SWENSON EVAPORATOR CO. ESTABLISHED 1889

SWENSON

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It appears that ample supplies will be available in 1949, and that prices will be greatly dependent on whether the Government loan program is renewed in 1949 and the levels at which loan values are established. As in recent years, the increased proportion of gum rosin made in modern central stills will result in the production of large percentages of pale grades with correspondingly smaller proportions of dark and medium grades.

CASEIN

Based upon preliminary calculations, there has been no significant change in the rate of casein consumption during 1948 as compared with 1947 although volumes consumed during both of these years were substantially below prewar levels. As the year opened, prices were quoted generally in the range of 30 to 32c per pound and thereafter declined gradually to a level of approximately 25c per pound at the end of September. It is difficult to predict price trends through the winter months, but with substantial stocks now being held in the Argentine, it is doubtful prices will advance materially.

The outlook for 1949 is still obscure with much depending upon the future attitude of the Government in connection with European relief. Continued heavy foreign demand for edible milk products, and especially for nonfat milk solids, could again restrict the volume of domestic casein production and prevent substantial price reduction.

It is expected total supplies of casein through 1949 will be ample. Present indications point to increased domestic casein production although it is highly improbable it will satisfy requirements, and users may again be forced to rely heavily upon imported material.

ALUM

The consumption of alum by the paper industry has remained high during the year 1948 and is about equal to full plant capacities. Except for a few short periods during the year, mill requirements were met in full. There has been no change in quality or in uses for commercial alum. Prices have advanced to offset increased production costs. Increases were generally within 20%.

There has been no change in the supply or demand of iron-free alum during the year 1948. The quality has remained equal to or better than prewar grades. Prices advanced approximately 25% to offset higher production costs. No change in price, quality, availability, or use is expected during the coming year.

SODIUM ALUMINATE

There has been no important change in supply or demand of sodium aluminate during the past year. Requirements have been met in full and the quality has remained high. No change in the demand or supply of sodium aluminate is expected during the coming year. Prices have advanced but very slightly.

SODIUM PEROXIDE

The demand for sodium peroxide continues to be greater than the supply. The market price for sodium peroxide has been increased 2 cents a pound.

The use of sodium peroxide for bleaching groundwood has increased considerably in 1948. Bleaching mixtures of groundwood and sulphite pulp with sodium peroxide has been put into commercial operation on a substantial scale. Sodium peroxide has been introduced commercially for deinking waste papers. From a technical point of view hydrogen peroxide and sodium perborate are interchangeable with sodium peroxide for the applications in the pulp and paper industry. Economic considerations govern the choice of a peroxygen compound for these uses. In view of the short supply of sodium peroxide some pulp and paper mills are using a combination of hydrogen peroxide and sodium peroxide or hydrogen peroxide alone.

A shortage in the supply of sodium peroxide is expected to continue in 1949.

STARCH

There have been no important changes in the consumption of starch in the paper industry and the demand is strong for all of the important uses. There was a slight decline in the price of corn starch. Since the crop estimates indicate that the 1948 corn crop will be the largest in history, starch will probably be more available and the price lower in 1949.

There have been no major new uses for starch in the paper industry. However, the demand remains strong for the use of starch in beater sizing, surface sizing, calender sizing, and paper coating. There is also considerable starch being used for laminating, corrugating, and the pasting of paper bags. In paper coating there has been a trend toward the use of lower viscosity starches of both the oxidized and dextrinized types. New starch derivatives have also appeared on the market but these are too high-priced for most purposes.

GLUE

It is expected that bone glues will remain in their present fairly free supply. However, the situation on hide glues, particularly for the first half of 1949, may be expected to remain in extremely short supply, unless there is a terrific drop in general business.

Hide glue production for the most part is contingent upon leather production by the tanning industry. Tanneries have been operating on a 5-day week basis and some have closed down entirely which has resulted in an extreme drop in raw material receipts by the producers of hide glues from their main sources of supply.

Until this situation is relieved, it will be necessary to continue allocating hide glues on a month-to-month basis in keeping with the limited receipts of raw stock. Any prediction as to when leather production will increase with its attendant release of raw hide trimmings for glue manufacture would be pure guesswork.

DYESTUFFS

The large demand for dyes has continued so far this year at about the same rate as during 1947. Production has been at the highest level in history.

Prices of dyes on the average increased 10% over 1947 and are approximately 27% above 1939. In general, the standard quality of production was very well maintained.

revival: *putting new life into a plant*

Give a lift to your slitting
and winding operations by
installing a *Langston!*
The improved method of slitting,
sturdy construction and other features
make Langston Slitters and
Roll Winders unbeatable.
Samuel M. Langston Company,
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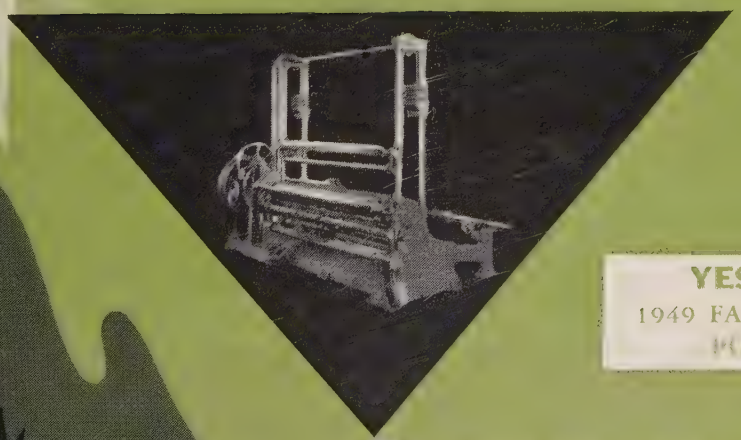

YES: GO WEST!
1949 FALL MEETING TAPPI
PORTLAND, ORE.

Langston

SLITTERS AND ROLL WINDERS

SUPERFINE FILLER

TUFJEL 97

MAKES BRILLIANT WHITE PAPERS

SAVES BLEACHED SULPHITE COSTS

ADDS STRENGTH TO SHORT FIBRES

TISSUE FILLER *makes brighter white papers.*

TISSUE FILLER *saves bleached sulphite costs due to its intensely white color.*

TISSUE FILLER *produces brighter white papers from ground wood and unbleached sulphite.*

A. M. MEINCKE & SON, INC.

7 SOUTH DEARBORN STREET
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There were no substitutions other than the substitution of certain standards for others which were temporarily unavailable. The outlook for the coming year, with respect to availability, is that adequate supplies of dyes will be available to the paper industry. High rate of production will be maintained.

CLAY

Production of machine-coated book papers and of clays for their manufacture has shown marked increases, as expected. Further substantial increases in productive capacity for these grades of paper are anticipated to be in operation before the end of the year.

Demand for coating and filling grades of domestic clay continued strong through the Spring and into the Summer. The domestic producers were hampered during the early months of 1948 by unusually severe weather which, through its interference with mining operations and curtailment of fuel supplies, hampered output until early in April. However, no paper mills suffered shutdowns because of lack of clay. Demand for all grades slackened seasonably in mid-Summer, but domestic coating clays are expected to continue in tight supply.

Coating-clay prices increased about $1.00 per ton in the late Spring. Filler prices were generally steady. Quality of both coating and filler clays was well maintained with indications of improvement. On machine-coating clays, in particular, the leading domestic producers are making great efforts through research and improved facilities for better quality and greater uniformity.

ZINC SULPHIDE PIGMENTS

The tendency to use lighter weights of paper, while attempting to maintain opacity, continues to result in a heavy demand for technically pure zinc sulphide, cryptone (containing approximately 50% zinc sulphide), and lithopone.

The postwar demands from all markets served by the various grades of zinc sulphide pigments have resulted in a very tight situation. The necessary increase in price of technically pure zinc sulphide to $13^1/_2$c per pound has in no way alleviated this situation. Lithopone, now selling for $6^3/_8$c per pound, is somewhat more free and from time to time is available.

WAX SIZES

With respect to the consumption of wax size, there has been a slight increase due to a replacement of rosin size for certain specialized internal sizing problems. The price trend seems to be downward due to the small reductions which have been made in the price of the waxes going into wax emulsions. The outlook on the price for next year seems to be one of no change or possibly further slight reduction in price. The availability looks very good unless the international situation is changed within the next few months.

DEFOAMERS

With respect to the consumption of defoamers, there has been a slight increase in this line due to a trend toward replacement of toxic and odoriferous defoamers which have been used in pulp manufacture and in some of the coarse grades of paper and paperboard.

The price variations have been upward and downward, but the over-all trend seems to be downward. The price on defoamers in general is tied closely to the price of raw fats and oils and the price trend at this time has been difficult to forecast because of political manipulation which have in turn affected the fat and oil price structure. The availability for the coming year of materials going into the defoamers seems very bright.

SYNTHETIC RESINS

During the year of 1948 a steady growth in business on the thermosetting resins for wet strength paper was noted. It appears that during 1948 many mills converted to specialties in efforts to improve their grades and this influenced the improvement in the tonnage of wet strength paper produced. Likewise, those wet strength papers which became established during the past years enjoyed an expanded use resulting in increased tonnage. The bag field, in particular, has produced many specialty wet strength bags including such items as paper bags for marketing ice. Prices, in general, for urea and melamine resins in the wet strength field have remained firm throughout the year up to the present writing. Increased interest has been exhibited by mills who have not heretofore produced wet strength paper as they tend to specialize their grades a little further.

Of noteworthy interest is the increased interest of mills to use the thermosetting resins as a means of increasing other properties in their papers than wet strength. Some mills are using small quantities of resins for improving the dry strength qualities, improving the pick resistance of the paper, and for reducing the surface "fuzzing" of their papers.

With the general increased interest in the use of thermosetting resins, it is anticipated that 1949 will see an even greater use of these resins, particularly as more and more paper manufacturers investigate the possibilities of resins in their paper. Increased interest in the dry strength possibilities of the resins for many printing grades of paper was indicated by Charles G. Webber of the National Bureau of Standards in his article that was published in 1948, which pointed the way to the possible increased use of hardwood fibers to replace the softwood fibers through use of thermosetting resins, particularly of the melamine type, to obtain increased bonding and strength necessary in printing paper. No price increases are in the immediate sight and any adjustments will, no doubt, be governed by general economic conditions.

During 1948 a new type of paper resin was introduced which produced wet strength in paper yet markedly increased its over-all strength characteristics. This material must be applied at the size press or calender stacks and will improve dry tensile, burst, fold, pick, abrasion resistance, and dimensional stability. Dry tear is not adversely affected.

Consumption of alkyd resins for use as paper coatings continues on a large scale. It is estimated that consumption of alkyd resins for this purpose will be somewhat larger than in 1947. Prices of alkyd resins have dropped during 1948 due to reductions in the

costs of raw materials which in turn are derived from agricultural commodities. The availability of alkyd resins is good at the present time and it is not anticipated that their supply will be restricted over the coming months.

Acrylic resins continue to be used in moderate quantity as paper coatings. No significant increases or decreases in the price of acrylic resins have occurred during 1948. The outlook for availability of acrylic resins in the months to come is excellent, and manufacturers of these resins do not anticipate any difficulty in meeting demand.

STARCH CONVERTING ENZYMES

The usage of amylolytic enzymes in the paper industry continues to increase. Enzyme converted starches are used for all types of starch applications, including sizing, coating, and laminating. More widespread use of automatically controlled starch cooking equipment tends toward better and more uniform conversions. In addition to time and temperature controlling equipment, there is now available a new viscometer for automatically controlling and recording the viscosity of starch dispersions.

The strength of most of the commercial enzymes is now standardized and controlled within narrow limits and new high-strength dry enzymes have been developed.

There has been no increase in the price of normal strength enzymes during the past year. The price of the high-strength enzymes is slightly lower per unit of starch converting strength.

The supply of amylolytic enzymes is ample to meet all normal demands.

PLASTICIZERS

The position of nearly all plasticizers has shown a marked improvement during 1948. In general, production has been increased as raw materials became more plentiful while in a number of cases enlarged manufacturing facilities are helping to take care of increased demands. Predictions for the future are optimistic on almost all materials listed and, barring unforeseen upheavals, the availability of plasticizers is expected to show continued improvement.

GLYCERIN

Supply and demand are said to be in fairly good balance at the present time and orders are being filled promptly. Some concern is being felt over an apparent scarcity of crude glycerin which has resulted in low working inventories at refiners' plants and which would disrupt the even flow of refined grades to consumers should it become more marked. To offset the present shortage of crude, natural glycerin it is expected that the long-awaited production of synthetic glycerin will soon be under way. Plant capacity has been estimated as 30,000,000 pounds per year, or roughly 18% of natural glycerin production. This estimated output is already booked on contracts, but it is hoped that production will eventually exceed the estimate, leaving a surplus available to the general market.

Glycerin prices have remained firm in 1948; high gravity glycerin in drums being 39.5c per pound in car lots and 40c l.c.l. These prices represent an advance from the low point of 1947 but are substantially under the high levels reached early in that year.

INVERT SUGAR

The outlook for sugar supplies is favorable at present. Official World estimates show a good balance between supply and demand to production of such 1948. As for 1949, the return to production of such normal United States' suppliers as the Philippine Islands appears to promise an even more satisfactory position. Orders are being filled promptly, which condition is expected to continue.

Prices in 1948 have shown a decline from the highs of 1947, with current quotations ranging from $7.50 to $8.00 cwt., drums, f.o.b. works. Predictions for 1949 do not indicate any great change in these prices.

SORBITOL

Increased production has greatly improved the situation with immediate deliveries being the rule. New production facilities have resulted in the marketing of a 70% solution meeting with favorable reception. Prices on the standard grade have remained firm at 25.5c per pound in drums, carload and 26c l.c.l. The 70% solution is now quoted at 17.6c in tank cars and 18.2c in drums, carload.

UREA

Production has been largely increased, but due to extensive demands the available supply is still not as ample as could be desired. Orders from regular consumers are being filled fairly promptly and, while new business is not being actively sought at present, it is pointed out that any slackening of export demand would automatically improve the domestic situation. New production facilities are expected to be in operation shortly.

Current prices at 4.25 to 4.75c per pound are somewhat advanced over 1947 levels.

SODIUM NITRATE

Sodium nitrate is reported currently to be in short supply with producers and importers not inclined to book contracts at the present time. No hopes are held for immediate improvement. Prices are firm with crude, domestic quoted at $45.50 per ton in bags, carload and $42.00 in bulk cars.

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Passage of Materials Through Wood, Paper, Cellulosic Membranes, and Fabrics

ALFRED J. STAMM

AN UNDERSTANDING of the ways in which gases, vapors, liquids, and solutes pass through cellulosic materials under different motivating forces is not only of theoretical interest, but also of considerable industrial importance. An understanding of the conditions controlling the passage of liquids into wood is of importance in treating solid wood and veneer with preservatives, fire retardants, and dimension-stabilizing chemicals, and in treating wood chips with pulping chemicals. A knowledge of the mechanism of liquid removal from wood is of importance in the drying of wood in all forms. An understanding of the permeability of paper and various cellulosic-film materials to water in both vapor and liquid forms is of importance in packaging numerous commodities. Permeability information is also of importance in using these materials as filters and osmotic membranes. The permeability of fabrics is of importance from the standpoints of allowing the evaporation of perspiration through clothing and at the same time excluding the passage of liquid water in the form of rain.

No attempt will be made to cover the material in a chronological, historical manner, or to include a complete bibliography of the subject. The subject matter will be subdivided according to the type of motivating force and operative conditions. Different means of obtaining and analyzing data under each of the different conditions will be given for the different types of cellulosic materials, and possible general conclusions be drawn.

Materials can move through a porous structure as a result of (1) externally applied pressure, (2) capillarity, or (3) diffusion resulting from a concentration gradient. The movement under externally applied pressure may, in the simplest case, occur under conditions such that no liquid-gas menisci are formed within the capillary system. The more common case, however, involves such menisci, as do all cases involving capillarity alone. Diffusion does not involve the presence of menisci, but systems in which diffusion is taking place may be complicated by superimposed capillary-movement conditions.

PRESSURE PERMEABILITY

The relatively simple case of flow of a fluid through a capillary system in which menisci are absent, will be considered first. The rate of flow, V, of a fluid with viscosity, η, through a single small-bore capillary with a radius, r, and length, l, under pressure, P, may be expressed by Poiseuille's law as follows:

$$V = \frac{\pi r^4 P}{8\eta l} \qquad (1)$$

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The flow through several such capillaries in parallel is the sum of the flow through each alone. Hence,

$$V = \frac{n\pi r^4 P}{8\eta l} = \frac{qr^2 P}{8\eta l} \qquad (2)$$

in which n is the number of capillaries and q is the combined cross-sectional area of the capillaries. These equations indicate that the rate of flow is highly dependent upon the size of the capillary. If the larger of two capillaries in parallel has a radius 10 times that of the smaller, the flow through it will be 10,000 times that through the smaller tube. If these two capillaries are connected in series rather than in parallel, the flow through each has to be the same. In this case the pressure drop through the smaller capillary will have to be 10,000 times that through the larger capillary. Equation (2) thus holds exactly only for uniform-bore capillaries with the same radius.

The flow of a fluid through wood sections, paper, various membranes, and fabrics is very complicated because these materials are made up of complex capillary systems in which each capillary varies in radius along its length and each has a different effective radius and length. Hence, most of the studies of such complicated natural and artificial capillary systems have been confined merely to measuring the rate of flow through the material under different conditions. Maass and co-workers (*20, 42*) have shown that the rate of flow or permeability of water through sapwood sections may be 200 times that of heartwood. They have also shown that the longitudinal permeability may be 50 to 100 times the transverse values. Buckman, Schmitz, and Gortner (*7*) have shown that the permeability of wood to water decreases with time. It is still uncertain if this is due to electrokinetic effects or to plugging of the fine communicating capillary structure by small particle impurities in the water. Silvio (*33*) has shown that the permeability of paper is not a linear inverse function of the thickness, presumably because of poorer orientation of the fibers in the thicker sheets. Doughty, Seborg, and Baird (*12*) determined the equivalent pore radius (radius of a single pore that would give the experimental rate of flow) for various papers. The equivalent radius was shown to decrease with an increase in the solid fraction. McBain and Kistler (*27*) have shown that cellophane, which is permeable to water but not to less polar liquids, becomes permeable to the latter upon replacement of water with those liquids.

Pore radii have been determined from water-permeability data, using equation (2), on the basis of various assumptions regarding the nature of the capillaries. Duclaux and Errera (*13*) assumed that the capillaries in cellulose acetate membranes are circular

in cross section with a uniform bore, all arranged at right angles to the faces. They determined q from the moisture content of the saturated membranes. In this way they found the average effective capillary radius to be 13 mmu (13×10^{-7} cm.). Bjerrum and Manegold (*6*) and Morton (*29*) also assumed that the capillaries have a uniform bore but that they extend in all directions without intersecting. Bjerrum and Manegold obtained average effective pore radii of collodion membranes ranging from 0.9 to 30 mmu, and Morton obtained 1.5 to 9.4 mmu for cellophane. Hitchcock (*19*) determined the effective value of q/l from the electrical conductivity of collodion membranes saturated with a salt solution sufficiently concentrated to overcome surface-conductivity effects. He thus did not have to make assumptions as to the direction of the capillaries. He obtained values for collodion membranes ranging from 3 to 20 mmu.

The author (*35*) has shown that the permeability of wood to the flow of water is determined by the cross section and size of the pit-membrane pores that serve as the communicating structure between the fiber cavities. From equation (2) the following equation was deduced for flow in the longitudinal direction through the heartwood of coniferous species:

$$\frac{Ar_f^2}{l_f} \times P_f = \left(\frac{q_p r_p^2}{l_p} + \frac{q_w r_w^2}{l_w}\right) P_p \qquad (3)$$

in which A is the average cross section of the fiber cavities per unit area of wood calculated from the bulk density of the wood and the density of the wood substance (*38*), r_f is the average radius of the fiber cavities determined microscopically, l_f is the effective length of the fiber cavity; q_p, r_p, and l_p are, respectively, the effective cross section, average radius, and length of the pit-membrane pores per fiber; q_w, r_w, and l_w are the corresponding quantities for the transient cell-wall capillaries, to be described later; and P_f and P_p are the pressure drops through the fiber cavities and the communicating structure, respectively. Substituting experimental and estimated values for the cross sections, radii, and lengths of the various capillary structures in equation (3) gives:

$$53{,}000\, P_f = (3 + 0.0007) P_p \qquad (4)$$

which reduces to

$$P_f = 5.7 \times 10^5 P_p \qquad (5)$$

Equation (4) indicates that the flow through the cell walls is negligible in comparison to that through the pit-membrane pores (3 as compared with 0.0007). Equation (5) shows that the pressure drop through the fiber cavities is negligible in comparison with that through the pits. It is thus evident that flow of a fluid through wood is dependent almost entirely on the permeability of the pits. A similar situation has been shown to hold for flow through wood in the transverse directions (*40*).

The author has determined the average effective pit-membrane pore radius from permeability measurements on the basis of the total pressure drop occurring through the pits with the permeability of the cell walls being considered negligible, and using values of q_p obtained from electroosmotic flow data (*35*). Values of r_p of 16 mu were obtained in this way for western red and Alaska cedar (*40*).

Carson (*11*) determined the average effective pore size in paper from air-permeability measurements without having to determine the effective capillary cross section, as in the case of the previously cited measurements. He did this by using Meyer's modification of Poiseuille's equation:

$$V = \frac{n\pi r^4 \Delta P}{8\eta l}\left(\frac{2P - \Delta P}{2P}\right)\left(l + \frac{4S}{r}\right) \qquad (6)$$

in which ΔP is the pressure drop through the paper, P is the applied pressure, S is the mean free path of the gas, and other symbols have the same significance as in equations (1) and (2). When measurements are made under two different applied pressures, P and P', then

$$Ps = P's' \qquad (7)$$

and

$$\frac{r + 4S}{r + 4S\dfrac{P}{P'}} = \frac{V/\Delta P(2PP' - \Delta PP')}{V'/\Delta P'(2PP' - 4P'P)} \qquad (8)$$

In this way Carson obtained values for r ranging from 0.2 mu (0.2×10^{-4} cm.) for double-coated book paper to 1.2 mu for bond paper.

Another modification of Poiseuille's equation by Kozeny (*23*) makes it possible to estimate the extent of the internal surface through which flow occurs. This subject is covered in Dr. Campbell's review.

OVERCOMING SURFACE TENSION

The radius of a glass capillary that is wet by a liquid, can be determined from the capillary rise and the surface tension of the liquid. The height of capillary rise cannot be observed, however, in most porous systems and, moreover, when the capillaries vary in bore along their length, the position as well as the variation in size of the different bores will affect the measurements. It is possible, however, to measure the air pressure necessary to overcome capillary rise by determining the pressure that will just allow air to pass through a previously liquid-filled capillary system. This pressure, Q, is related to the capillary radius, r, and the surface tension of the wetting liquid, σ, as follows:

$$r = \frac{2\sigma}{Q} \qquad (9)$$

The radius, r, represents the smallest bore of the capillary that has the largest small bore of all the capillaries. Bigelow and Bartell (*5*) checked the capillary size measured, using a number of capillaries with different bores in both parallel and series combination. Bartell and Carpenter (*1*) found this most effective pore radius to range from 300 to 800 mmu for the collodion membrane-water system. McBain and Kistler (*27*) obtained values ranging from 20 to 30 mmu for cellophane. The author (*35, 36*) obtained values ranging from 40 to 5000 mmu for the pit-membrane pores of heartwood of coniferous species. Cross sections with thickness just exceeding the maximum fiber length gave the larger values. Thicker cross sections and radial and tangential sections in which the water-air meniscus has to be forced through a number of pit membranes in series give smaller values as the probability of the largest openings occurring

in the same series path decreases. Quite thick sections should give values approaching those for the approximate average pore size determined by other methods.

Very high pressures amounting to several atmospheres have to be applied to force the water-air menisci through small membrane pores. Bechhold and coworkers (*4*) felt that such pressures might deform the membranes, even when supported by a metal grid. They displaced water with isobutyl alcohol. The interfacial tension was only 1.8 instead of 72. Hence, they were able to make their displacements with only $^1/_{40}$ of the applied pressure used by those who displaced water with air. They obtained values for the minimum radius of the most effective pore in parallel in collodion membranes ranging from 90 to 250 mmu.

Bechhold (*3*) has determined the distribution of pore sizes in collodion membranes by combining the method of overcoming surface tension with the method of pressure permeability. When the pressure is increased beyond that necessary to displace water with air, displacement occurs from the next most effective capillary. At the same time the rate of flow of air through the capillary from which water was first displaced, increases in proportion to the increased pressure. The rate of flow of air will thus increase faster than in direct proportion to the pressure increase. The rate of change of permeability per unit change in effective radius can thus be calculated from the increased rate of flow over that proportional to the applied pressure. Bechhold obtained such distribution curves for several different collodion membranes. The membrane with the smallest pore range, 30 to 90 mmu, had a most probable radius of 55 mmu. Komagata (*22*) made similar measurements on collodion membranes. He obtained pore radii ranging from 30 to 60 mmu in the finer and from 130 to 300 mmu in the coarser membranes.

CAPILLARY RISE

Capillary sizes in paper have been estimated from the rate of capillary rise of a liquid in the sheet direction by using a theoretical equation deduced by Lucas (*24*). He combined equation (1) for the rate of capillary flow with the simple equation for the static height of capillary rise, as follows:

$$h^2 = \frac{r\sigma t}{2\eta} \qquad (10)$$

in which h is the height of capillary rise in time, t, of a liquid with a surface tension, σ, and viscosity, η, and r is the radius of a uniform straight capillary that will give the same rise as the irregular capillaries in the paper. Simmonds (*34*) applied the method to cartridge and blotting paper and obtained values varying from 10 to 40 mmu for the former and 100 to 300 mmu for the latter. The ratio of the capillary sizes in machine direction to those across the machine direction varied from 1.1 to 1.7 for the different papers. Foote (*16*) obtained values ranging from 155 to 350 mmu for sulphite bond paper. Peek and McLean (*31*) obtained considerably larger values for filter paper, namely, 4000 to 40,000 mmu. The reason for this is not apparent.

CAPILLARY CONDENSATION

Pore radii have also been estimated by the application of the Kelvin equation relating the radius of a capillary, r, and the relative vapor pressure of a contained drop of liquid, p/p_0, thus

$$r = \frac{2\sigma M}{\rho_0 RT \ln \frac{p_0}{p}} \qquad (11)$$

in which σ is the surface tension, M the molecular weight, ρ_0 the density of the liquid, R the gas constant, T the absolute temperature, and ln the symbol for the natural logarithm. This equation has been shown to hold for capillaries of considerably larger than molecular dimensions. It has been used to estimate the size of capillaries in the molecular range, even though it may be in error by several hundred per cent, merely because it is the only present known means of estimating the size of very fine capillaries within the cell wall of a fiber, which will be called "transient cell-wall capillaries" to emphasize the fact that they exist only when caused by swelling. From a moisture content-relative humidity curve and the density of adsorbed water, it is possible to obtain a relationship between the volume of water held in capillaries of different size (Fig. 1) (*40*). From the slopes of this relationship a dV/dr versus r curve can be plotted (Fig. 1). Since the most probable capillary radius thus obtained is only slightly greater than the diameter of a water molecule, this value has little real significance. The mean radius (radius of capillary above and below which half of the volume of water is held) is 4.0 mmu. This value is quite similar to the estimated value of 5.0 mmu for the average radius of transient cell-wall capillaries of a cellulose fiber arrived at by Frey-Wyssling from x ray measurements of silver crystals deposited within the fiber.

The author (*40*) has used the data for the sizes of the transient capillaries within the cell walls of wood to calculate an approximate effective capillary cross section of the cell wall. Previous attempts in determining the effective capillary cross section of membranes have been made on the basis of uniform-bore capillaries extending at right angles to the faces (*13*), uniform but not intersecting capillaries extending in all directions (*6*), and an intercommunicating capillary system between pecked spheres (*14*). None of

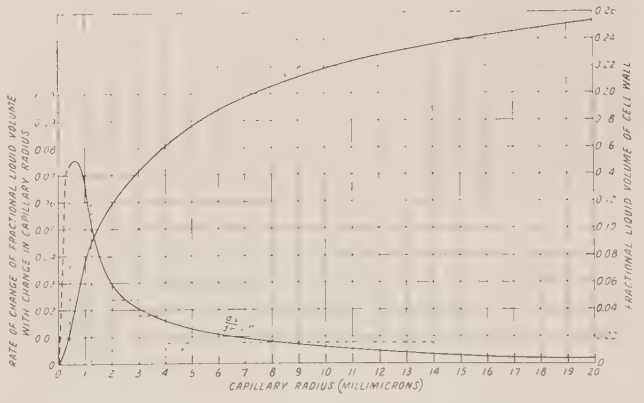
RATE OF CHANGE OF FRACTIONAL LIQUID VOLUME WITH CHANGE IN CAPILLARY RADIUS
FRACTIONAL LIQUID VOLUME OF CELL WALL
CAPILLARY RADIUS (MILLIMICRONS)

Fig. 1. Curve V, r, fractional liquid volume-capillary radius relationship; curve (dV/dr), r, distribution of capillary sizes in the cell wall of swollen wood, obtained by graphically differentiating curve V, r

these approximations appear reasonable for cellulosic membranes or cell walls. The capillaries are, undoubtedly, communicating, but they are between fibril threads rather than spheres. In the case of the cell wall, which is made up of fibrils arranged approximately parallel, the distance between fibrils should vary from zero to several hundred millimicrons with a monomolecular layer of water immobilized on all surfaces. On the average, any pair of fibrils should have capillary spaces between them such that all capillary size increments shown in Fig. 1 are present with lengths proportional to the corresponding fractional volume increment divided by the volume of unit length of this size of capillary, with all capillary volumes and radii being corrected for a monomolecular layer of water that has been immobilized on the capillary surfaces (*40*). On this basis, the greatest proportion of the capillary lengths is made up of the smallest capillaries. Capillaries that have an effective radius no greater than the diameter of a water molecule, can hardly be effective for the passage of other molecules. Such a large proportion of each capillary path is made up of these small capillaries that they would all be ineffective for passage of molecules, even as small as the water molecule, if they were not intercommunicating. Because the capillaries existing between a bundle of fibrils are intercommunicating, any material passing through the fiber can shift from one path to another to avoid the impermeable zones. It was thus estimated that a molecule passing through the cell wall in the fiber direction must shift, on the average, 12.5 times from one path to another. When the fractional void volume of a cell wall is 0.284, immobilizing of a molecular layer of water reduces the value to an effective fractional void volume of 0.192, and the increased path further reduces it to an effective fractional void cross section of 0.0154 for longitudinal passage. The corresponding effective fractional void cross section for passage across the fibers is 0.0078. These values will be shown to be reasonable approximations in connection with diffusion studies.

The author (*37*) has also used equation (11) as a means of determining the distribution of pore sizes in the pit membranes of coniferous woods, in combination with pressure-permeability measurements. The permeability of wood sections to air of different relative humidities was determined. The permeability decreased linearly with an increase in the equilibrium moisture content up to about 20% moisture content, which indicates that the pit-membrane pores decrease in size as the wood swells. Above this moisture content, the permeability drops off rapidly due to condensation of water first in the smallest and then in the larger communicating openings. The capillary radius in which condensation occurs at each of these high relative-humidity values can be calculated from equation (10). A curve can then be plotted for the change in velocity of flow per unit loss in effective capillary radius due to condensation against the radius. This gave a most probable capillary radius for Western white pine of about 27 mmu, which is somewhat larger than the value 16 mmu obtained for cedars from pressure-permeability measurements (*35, 40*).

ULTRAFILTRATION

From ultrafiltration studies it is possible to estimate the order of magnitude of capillary sizes when the size of the particles is known. Bechhold (*3*) and Elford (*15*) have made most of the measurements of this type. Bechhold found that the diameter of the capillaries must be 8 to 15 times larger than the particles that can pass through them. Elford found that the capillary need be only slightly to 3 times as large as the particle. The author found (*39*) that softwood cross sections thicker than the maximum fiber length, would allow the passage of a mercury sol containing particles having a diameter of approximately 8 mmu. This size is one half to one fourth of the most probable capillary size obtained by the previously reported methods. The fact that the capillaries have to be appreciably larger than the particles that can pass through them, is attributed to adsorption and electrokinetic phenomena.

DIFFUSION

Diffusion through a capillary system differs from flow of a fluid through the system in that it is dependent only on the effective capillary cross section and not on the actual size of the capillaries. Diffusion measurements across a liquid-saturated membrane have been used as a means of determining the diffusion constant of a solute and as a means of studying the structure of the membrane.

Northrup and Anson (*30*) and McBain and Liu (*28*) used fritted-glass membranes to separate a solution from the solvent and determined the diffusion of the solute through the membrane by analyzing samples of the mixed liquid taken at intervals from both sides. The diffusion constant of the membrane is determined by first making measurements with potassium chloride as the solute, the diffusion constant of which is accurately known, followed by measurements with other solutes. The experiments show that diffusion constants for materials of a broad range of molecular weights can be thus determined. Evidently, only when the diffusing molecule approaches quite closely in size to the capillary diameter, are wall-interference effects important.

Lusby and Maass (*25*) have determined the relative rates of diffusion of a solute into small blocks of wood in the longitudinal and transverse directions by immersing blocks of the same volume, but having different ratios of length to cross section, in various solutions for various intervals of time. The times to attain half the original concentration at the center of the blocks gave a longitudinal diffusion three times as rapid as transverse diffusion with NaCl and HCl. In the case of NaOH the ratio of longitudinal to transverse diffusion was about 1. The large transverse diffusion with NaOH is due to swelling that opens up the transverse structure. Cady and Williams (*10*) studied the diffusion of urea, glycerol, and lactose into water-saturated wood. They obtained a ratio of longitudinal to transverse diffusion of about 9 (*40*).

The author (*40*) and Burr and the author (*9*) have shown that the diffusion of a solute into a liquid-saturated porous material, relative to its diffusion in

the bulk liquid, is equal to the electrical conduction of the porous material, saturated with a salt solution of sufficient concentration to overcome surface-conduction effects, divided by the bulk conductivity of the solution. These measurements indicated that the ratio of longitudinal to transverse diffusion of a solute into wood should be about 10 to 12. The values agree quite well with those of Cady and Williams, but not with those of Lusby and Maass. The discrepancy is believed due to the possibility that the blocks of wood used by Lusby and Maass were not completely saturated with water at the start of the experiments.

The author (*40*) has shown that the diffusion of solutes through water-saturated wood, relative to the diffusion of the solute in bulk, can be calculated from capillary data by using the electrical-conductivity analogy that diffusion through capillary structures in parallel are additive and the resistances to diffusion through capillary structures in series are additive. In both longitudinal and transverse diffusion the movement of solute is through the fiber cavities in series with the pit systems and the transient cell-wall capillaries, with the two latter structures being in parallel (Fig. 2). This combined system, in turn, is in parallel with continuous passage through transient cell-wall capillaries. The calculations involve the use of data

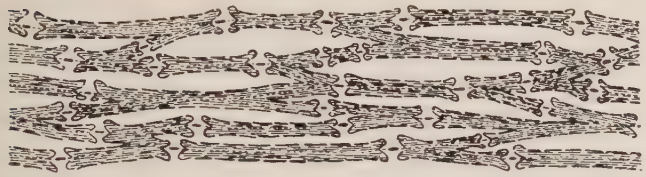

Fig. 2. Diagrammatic sketch of a swollen tangential section of a softwood

for the effective capillary cross section, capillary length, and number of each kind of capillary traversed in series per unit distance. The relationships show that diffusion of a solute in the fiber direction of coniferous species is almost entirely dependent upon the fractional cross section of the wood that is made up of fiber cavities and that is numerically equal in area to the fractional void volume. The parallel combination of pits and transient cell-wall capillaries offer considerably less resistance to diffusion in the longitudinal direction than do the fiber cavities, since the combined void cross section of the communicating structures, from one fiber to another along the fiber length is greater than the fiber-cavity cross section. It is of interest that capillaries as fine as the transient cell-wall capillaries are quite effective in diffusion, in contrast to the previously cited finding that they are practically ineffective in pressure permeability. The continuous diffusion through the transient-cell-wall-capillary system is practically negligible in comparison with that through the combined fiber cavities and pit and transient-cell-wall systems. The longitudinal diffusion of a solute through water-saturated wood is, consequently, a direct function of the void volume and an inverse function of the specific gravity of the wood (Fig. 3).

A similar analysis of transverse diffusion through coniferous species shows that the chief resistance to diffusion is through the parallel combination of pit systems and transient cell-wall capillaries (*40*). The continuous diffusion through the transient-cell-wall-capillary system again is practically negligible in comparison with that through the combined fiber cavities and pit and transient-cell-wall systems. The transverse diffusion through wood decreases rapidly with an increase in specific gravity below that of normal woods, and then decreases more gradually in the normal range of specific gravities (Fig. 3). These calculated diffusion values agree quite well with experimental diffusion and electrical-conductivity values when a fiber-taper correction is made for diffusion in the fiber direction.

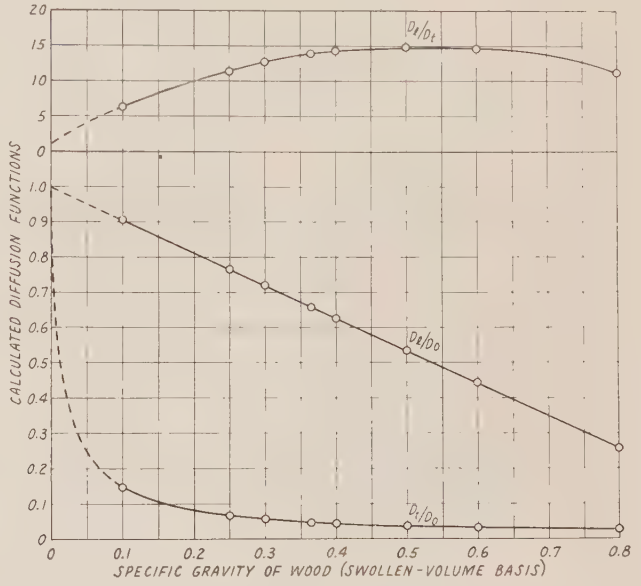

Fig. 3. Calculated diffusion functions relative to bulk diffusion for the passage of solutes with molecules the size of the water molecule through water-saturated wood of different specific gravities from the calculations of Stamm

The author (*40*) has also calculated the drying-diffusion constants for coniferous species in a similar manner. The calculations are complicated in that two types of diffusion take place simultaneously; namely, the movement of water vapor through the fiber cavities under a vapor-pressure gradient and the movement of bound water through the transient cell-wall capillaries caused by a moisture gradient. The two different motivating forces, in turn, are related by the complicated moisture-relative humidity curves. Besides this, a large part of the capillary structure changes in size from one lamina to another in the thickness direction as a result of moisture gradients. In spite of these complications, the calculated values for the transverse-drying-diffusion constant agree quite well with those calculated from moisture-gradient and rate-of-drying data by Fourier analysis methods (Fig. 4) (*2, 21, 26, 32, 44*). In the normal range of moisture content to which wood is usually dried (6 to 15%), the diffusion constants do not vary significantly with moisture-content boundary conditions. The diffusion constant increases with a decrease in the specific gravity of wood and with an increase in temperature.

The portion of the diffusion that is due to vapor diffusion, increases with a decrease in moisture content and a decrease in the specific gravity of the wood and an increase in temperature.

Diffusion of water vapor through cellulosic membranes and papers has been studied quite extensively in connection with packaging. The weight of water in the form of vapor passing through the material per unit of time under a supposedly definite relative-humidity gradient has been measured. The simple cup (*43*) or tray method is usually used, which involves sealing the sheet over a cup or tray containing

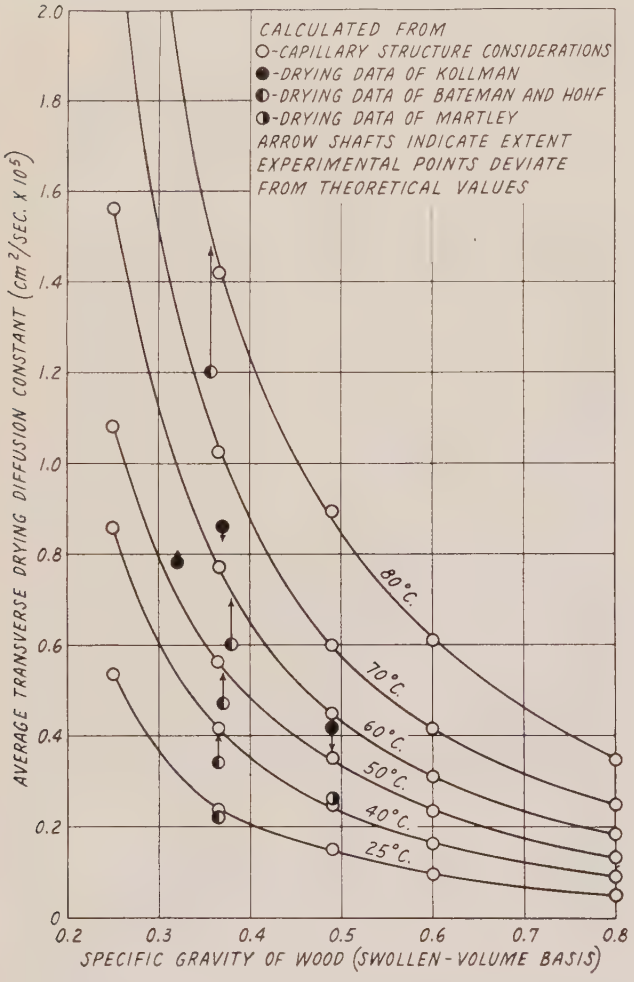

Fig. 4. Average transverse drying diffusion contants relative to unit dimensions of the wood, for wood with different swollen-volume specific gravities dried at different temperatures under relative vapor-pressure conditions which give a surface moisture content of 10%

water, a saturated salt solution that gives a definite relative humidity, or a drying agent, and exposing the cup or tray to a low or high fixed relative humidity and weighing it after various time intervals. The linear loss or gain in weight of the cup with time determines the vapor permeability of the sheet. This method gives approximately quantitative diffusion data only in the case of very impermeable membranes because of the fact that a humidity gradient resulting from the lack of stirring tends to exist in the air within the cups or trays. A voluminous amount of data has been obtained by this means on various papers, coated papers, cellulosic membranes, and plastics of all sorts. No attempt will be made to review these extensive data.

Burr and the author (*8*) have shown that with cellophane membranes the use of a special magnetic internal stirrer floating on water in the cup in some cases practically doubled the moisture loss per unit time. More rapid stirring did not further increase the rate of moisture loss. Measurements made with this apparatus on thin transverse sections of wood in both the normal density and compressed forms gave diffusion constants that are in good agreement with the theoretical drying-diffusion constants calculated from capillary structural data (*9*). Measurements on cellophane gave values of the same order of magnitude as the calculated values for the diffusion of water vapor through the cell walls of wood (*9*).

A number of measurements have been made on the diffusion of water vapor through fabrics. Of special interest is a paper by Fourt and Harris (*17*), in which they show that the resistance to loss of water vapor through glass fabric, vinyon, and nylon increases rapidly with an increase in the fractional fiber volume, whereas the resistance to loss of water vapor through cotton increases but slowly with an increase in fractional fiber volume. Water vapor passes only through the interfiber capillaries in the case of the glass fabric, and almost entirely through the interfiber capillaries in the case of vinyon and nylon. Consequently, as the void volume or cross section decreases, the resistance to passage of water vapor increases. In the case of cotton, an appreciable amount of water vapor condenses in the fiber, passes through the fiber under a moisture-content gradient, and re-evaporates on the other side. Even if the interfiber void volume were zero, some passage of water vapor would occur. This is in agreement with the authors' findings that water diffuses through wood in both the vapor and liquid forms.

A recent symposium sponsored by the Faraday Society was held at Southampton, Eng., on "The Interaction of Water and Porous Materials." This series of papers, accompanied by a stimulating discussion, should soon appear in the Journal of the Faraday Society. A large number of the papers and an appreciable part of the discussion is concerned with the important subject of wetting angles. This phase of capillary chemistry has been purposely omitted in this review because its inclusion would have unduly extended the subject matter.

Before throwing this topic open for discussion, it seems timely to remark that there is a great deal of available spotty information on the capillary considerations of cellulosic materials. Unfortunately, those who have worked on interesting methods of elucidating the capillary structure and nature of porous cellulosic materials, have applied their methods to too narrow a group of materials. Those interested in special materials have likewise used too few methods of study. As a consequence, there are still a number of questions to be answered and generalizations to be made. The author therefore hopes that this review and the discussion to follow will stimulate further research along these lines.

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DISCUSSION

Dr. Aiken: Thank you very much for the interesting review.

I would like to comment on the last remarks Dr. Stamm made on the measurement of diffusion or permeability of sheet materials. I think the error he pointed out—that of not having full pressure gradient across the sheet—is very true for permeable materials. This was suggested years ago by Brabender who found that, for very permeable materials of which Dr. Stamm has spoken, the effective humidity was much under 100%. However, for very resistant sheets the relative humidity was close to 100% because such a small amount of water was going through the sheet; therefore, I think that error does exist definitely in the case of permeable materials. In most measurements we are not interested in permeable materials.

Mr. Yundt: I have a question to ask concerning the rate of capillary rise for determining the average pore size of capillaries. I wonder if one of the factors has not been overlooked, and that is the question of the wettability of the fiber—whether a particular fiber wets easily and well or whether it will be wetted only with difficulty. For instance, if we were to use alcohol, and repeat the work using the different constants, would we not get a different value for our capillary dimensions in that the alcohol more easily wets these lignified fibers?

Dr. Stamm: Part of the measurements that I have given here were determined in several liquids, alcohol among them. There is a tendency for some variation, especially with a highly sized material, but for unsized sheets it does not seem to be so great. I can appreciate, however, the possibility of an error due to retarded wetting because, from an equilibrium standpoint, we can say: "Sure, water wets cellulose materials, but when you are thinking of a rate which is rapid, water is a poor wetting agent because it will stand like a drop of mercury on a dry sheet of paper, sometimes for minutes, before soaking in." This may be an important factor which can be checked only by making the measurements on identical sheets by other methods.

The capillaries which you measure in that case are not capillaries through the fibers but between the fibers. A large part may not be full capillaries but a half capillary. You can see the water ascending and do not have to look through any walls, so that it is really not a fiber capillary that you are measuring.

Dr. Adams: As I recall, Dr. Stamm, Peak and McLean worked principally with organic liquids—benzene, xylene, etc. Most of these probably give a zero contact angle with cellulose. Also, Peek and McLean went to great lengths to operate in an enclosed system so that the rate of capillary rise was not complicated by the evaporation of their liquid. Do you recall what liquids were used by Simmonds and by Foote?

Dr. Simmonds: I used water only.

Dr. Adams: Were any precautions taken to prevent evaporation in the course of the rise of the liquid?

Dr. Simmonds: The experiments were carried out under room conditions.

Comment: I believe it would be interesting to have comments that relate to the point referred to in the work of Buckman, Schmitz, and Gortner who found that the permeability of wood to water decreases with time. The rate of decrease varied in the case of the more polar materials. Dr. Stamm has suggested that this might be due to electrokinetic effects or to impurities in the liquid. I think there were impurities

in all of the various solvents and in the water with which they worked. Does anyone have any thought on why this rate of pressure permeability should decrease with the time of flow of the liquid through the pad?

Mr. Bublitz: Several years ago work was done at The Institute of Paper Chemistry regarding the relationship between air and oil permeability of paper; data were obtained to show that, when a specimen of paper was subjected to the oil permeability test, the apparent permeability fell off with increasing time, although I believe it was narrowed down to the fact that it was increasing application or volume of oil which went through the paper that determined the decrease in the permeability. It was not the time. In other words, you could run one test today, let the sheet stand, and run another test tomorrow; you would obtain a certain decrease which was more or less independent of the time which elapsed between the two tests. Further work showed that one of the causes of this decreased permeability was the moisture content of the oil used in the permeability test. The tests were first made with untreated oil, then with oil dehydrated with copper sulphate, and it was found that, with decreasing moisture content, the rate of permeability decrease was less. In other words, the lower the moisture content of the oil, the less apparent was the effect; the conclusion was reached that, if we could prepare a completely anhydrous oil, the permeability would not fall off at all with increasing application. Fuller details of this investigation can be obtained from the publication of Bublitz, Dappen, and Van den Akker [*Tech. Assoc. Papers* 31: 305–315 (1948)].

Dr. Aiken: It seems to me that, from those experiments, the decrease in rate is perhaps due to water absorbed at the surface. Does anyone have any thoughts as to why water from oil, other liquids, or water itself would cause this?

Mr. Yundt: I think Dr. Boyd Campbell's demonstration of the effect of water on a benzene dispersion of solvent-dried pulp gives the answer. Water will wet the pulp. As a matter of fact, simple filtration of transformer oil through dry filter paper is one method used in practice for the removal of traces of water from the oil. The water wets the pulp and is held there, and the oil goes through the filter pad.

Mr. Bublitz: That still does not indicate why there is no asymptote to this effect.

Dr. Aiken: Why, on the passage of water iself, will you get a greater rate and then find that this will fall off with time?

Dr. Stamm: The plugging theory might be further tested by reversing the direction of flow. The permeability should again increase as a result of the dislodging of plugs.

Mr. Bublitz: That experiment was tried with the oil. When the sheet of paper was reversed and the permeability test was run in the opposite direction, the initial permeability value was obtained; therefore it appears as though there were a flushing out.

Dr. Bror E. Anderson: Following the work of Buckman referred to earlier, I made a study with Schmitz and Gortner on this decreasing rate of flow. We found that, when the logarithm of the rate of flow was plotted against the logarithm of the time of penetration, a rather straight line resulted after the first few minutes of flow. We found that, after the flow had decreased by passage of double distilled water in one direction through softwood sections, the flow would increase immediately upon reversal of direction of flow. Usually the increase was a factor of several times and, in some cases, approached the original rate. However, when we would return to flow in the original direction, the rate would generally be no faster than before.

Although flow was not increased by such a period of backwashing, it could be increased very considerably by other means. Either a rapid succession of reversals of direction of flow, or a series of spurts in one direction would cause the rate to increase. This finding, together with other evidence, caused us to reject the theory of plugging by particles.

We did work on fiber pads also and found that, in many situations, they gave results similar to those

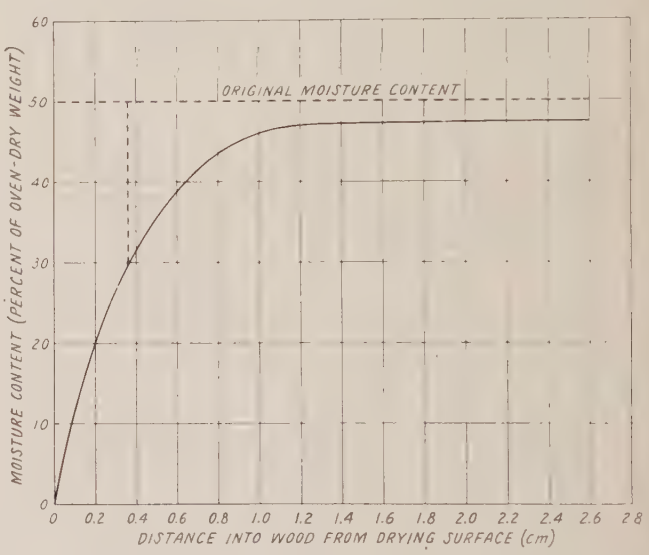

Fig. A

obtained with wood sections. A theory of the mechanism of this decreasing rate of flow was later developed, based on the action of simple models when drawn through water. A single, ribbonlike fiber model for instance, when suspended from the ends and drawn through water, would turn broadside to the direction of movement, thus tending to offer the maximum resistance to flow. When several models having rectangular cross section were suspended in space parallel arrangement, they did not orient broadside to flow but rather with one diagonal perpendicular to flow, thus giving the minimum width opening between each other and, therefore, again the maximum resistance to flow.

To apply this theory to softwoods, it is necessary to assume a submicroscopic fibrous structure for the pit membrane.

Dr. Aiken: There are a number of practical problems that come up in connection with cellulose materials that we might throw in for discussion. One of those that faces the wood industry is the drying of wood. Wood itself is not saturated with water. It has both water and air present. I would like to ask how

free water can be removed from wood in the drying process.

Dr. Stamm: It is interesting to consider the different types of moisture gradients that are obtainable in wood. For instance, the common one is a simple parabola (Fig. A). The curve is unaffected by a transition from the free-water movement range (above 30%) to the lower bound-water movement range. In a few instances, where the green wood is almost completely full of water, the free water is unable to move as a liquid from the filled fiber cavities. In such cases there is a sharp break in the curve at the fiber-saturation point (see Fig. B). As wood is never entirely free from air, the actual curve is between the theoretical curves for no liquid movement and free-liquid movement. The lack of movement of free water in the case of completely water-filled wood is similar to that in the analogous case of a bottle completely filled with water. Water will not run out unless air is able to enter. When the openings are small, as in the case of the communicating pits between fibers, a water-air meniscus can pass through the opening only by overcoming the effect of surface tension. This requires forces great enough to collapse the fibers. The water can evaporate but it cannot run out. If, however, all the fiber cavities contained some air, the air bubbles can expand under a relatively small tension and thus allow the water to flow out. Not only is it possible for the air to expand in the fibers adjacent to the zone at the fiber-saturation point but in any fiber within the specimen. The largest bubbles which will expand under the least pull will tend to expand first. Bubbles will expand only to the point where they have a smooth eliptical surface. Expanding to an irregular curved surface which will exactly coincide with the surface of the fiber cavity will require a greater pull. Hence, smaller bubbles in other fiber cavities will tend to expand first. Flow can thus occur through a fiber cavity containing an expanded air bubble along the irregular surface between the bubble and the cell wall. This adds resistance to the flow and tends to cause the expansion of the air in fibers nearest to the wet line before it occurs farther into the wood. Although this movement is not diffusion, it is caused by the drying forces resulting from the movement of bound water below the fiber-saturation point.

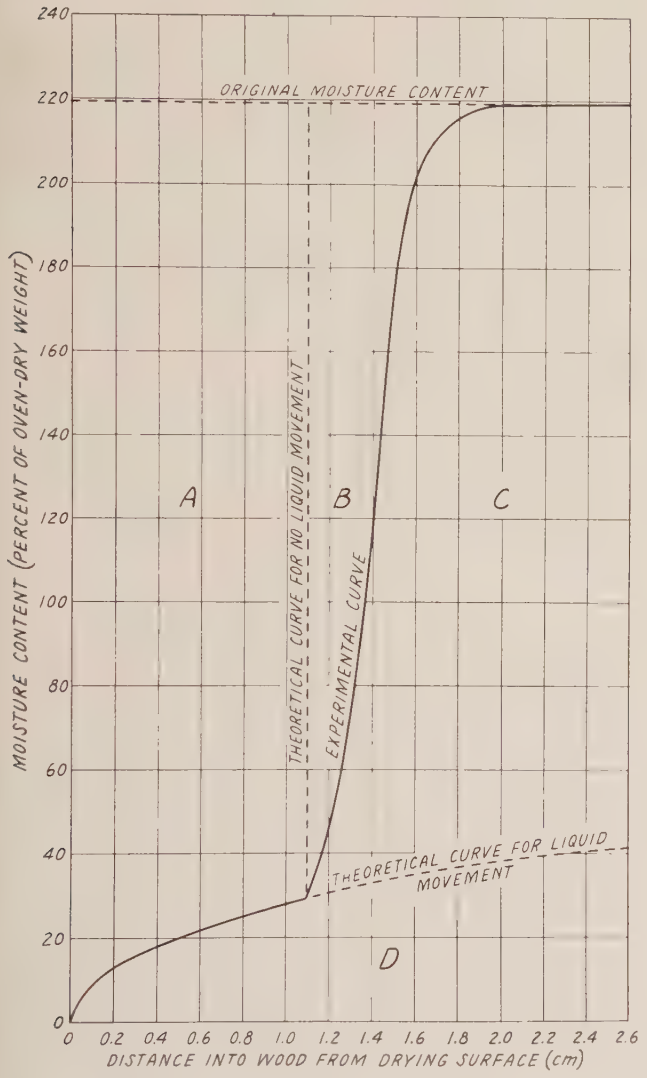

Fig. B

Dr. Aiken: I think a question of more interest is the penetration of cooking liquors into wood chips. This is a practical problem because cooking cycles are limited by the time required for penetration of the cooking liquors into the chips. Has anyone any idea of whether this is a matter of permeability, pressure flow, or diffusion? Has anyone done any work along that line? Or does anyone have any comment? Dr. Forman, in your cooking experience have you had any clue as to which it might be?

Dr. Forman: I do not think we have. I am not prepared to discuss that. It is one of those gaps for which we need a lot more information. It is extremely interesting, and we would like to know how the maximum penetration of cooking liquors of various kinds compares with the fundamentals that have been discovered for water and other pure liquids.

Dr. Stamm: It could be pressure permeability in the sense that you have applied pressure. The fact that your chip was not originally saturated means there were menisci there, so there could be capillary movement; to carry the cooking liquor ultimately into the cell wall, we know the last step has to be diffusion, but how much of the early process is diffusion and how much is the other, we cannot say. It can be all three. That makes it complicated.

Mr. Yundt: To reach the center of the chip, it has to be diffusion because the chemicals have been largely removed from the liquor as it penetrates the chip.

Dr. Gardner: It seems to me that, in considering the problem of pressure permeability, one would have to have at least some idea of the ability of the wood structure within the chip to maintain a pressure differential between the applied liquid pressure on the outside of the chip and the interior of the chip which, for at least an initial period of time, might be at a lower total pressure; this is a primary question of the ability of the wood to carry what is essentially a compressive stress. Perhaps Dr. Stamm would comment on that.

Dr. Stamm: What you say is undoubtedly true. We have no data to indicate that but it sounds very reasonable.

Dr. Shick: In the event the chips start below the fiber saturation point, air will be trapped in them. Some of this air will be forced out as the chips are heated to the boiling point of the water or liquor. This would still leave the chips filled with a mixture of air and water vapor. I would like to know what happens to these gases.

Dr. Stamm: In sulphite cooking do you not always have vapor present? I am not particularly concerned with pulping so I do not know.

Dr. Shick: You have gases present above the liquor in the digester, but I am concerned about the air originally in the chips. You are not forcing liquor through one end of the chip, but bringing it in from both ends and you have something inside the chip to begin with. What happens to this trapped air?

Dr. Stamm: Not being a pulp man, it has seemed to me desirable to put in a gas that is extremely soluble in water with the idea of it sucking in the liquor as it dissolves. There is a possibility of doing that. In wood preservation, we have what we call the hot and cold method. We heat the wood enough so that the air is expanded to the point where you have half as much as your normal amount of air. Then you plunge it into the preservative and chill it. The contracting air tends to soak in the liquor.

Mr. Yundt: That air contains oxygen too. In alkaline cooking, that oxygen will eventually be used up because it can combine with the carbohydrates. Perhaps some will combine with the lignin and be consumed in that way. I think lignin in alkaline solution will combine with gaseous oxygen. I wonder if your suggestion of replacing the air with a soluble gas would help by improving the degree of polymerization of the pulp?

Dr. Aiken: I wonder if anyone has had experience with preheating chips?

Dr. Forman: We believe a chip can be completely penetrated with liquor under pressure if given sufficient time. We believe we can speed up penetration by the artificial application of pressure during the penetration time. We believe that can be still further speeded up if pressure and vacuum are alternated. The latter is not usually considered commercially economical or feasible. We are working along some other similar lines which indicate that air can be driven out by steam and perhaps the speed of penetration can be improved thereby. We are not sure yet.

Dr. Aiken: I have a question to ask Dr. Stamm about diffusion. In the diffusion of vapors or liquids through the cell wall, how much of the diffusion takes place through openings already there and how much through areas momentarily opened through the movement of molecules of cellulose?

Dr. Stamm: In the case of pressure permeability, it appears that nothing goes through capillaries caused only by swelling. Those which I speak of as transient capillaries are so small that their effectiveness toward flow is negligible but, in the case of diffusion, it is not the size that counts but the number and the area. For this reason, in the case of diffusion, you may have quite an effective liquid diffusion through a transient capillary system. Even in a system where the major movement is vapor movement, when you come to an obstacle where there is no capillary big enough for vapor flow, it will condense and diffusion will occur as a liquid through the transient capillaries and then evaporate again on the other side. Hence, in a membrane in which all the capillaries are of the transient type, like in cellophane, the tendency for a moisture gradient to control the passage of moisture rather than the vapor pressure gradient is greater than in a fabric or in a sheet of paper.

Dr. Forman: In many of our pulping operations it is difficult for us to talk about penetration without talking of diffusion at the same time. We normally put the liquor on the chips and apply temperature and pressure right away. Undoubtedly, we may start some cooking before we have completely penetrated the chips, and some products of cooking are carried into the chip even though we want to get them out of the chip. Ideally, we penetrate the chip with some chemical first, then start the reaction at the right point and diffuse the products of the reaction out again. Ordinarily, we do not do that. Maybe studies along the right line will improve the process so that it will not degrade the material so much. It is hard to consider penetration alone without considering diffusion at the same time, but we need to know much more about both of them.

Dr. Max.: Some years ago I had occasion to pretreat wood chips prior to cooking. An alkali was used to swell the chips, after which the chemical was washed out as thoroughly as possible. Then during a following sulphite cook, as well as a following alkaline cook, there was reduced penetration in that the chip was cooked on the ends and incompletely cooked in the center; this seems to indicate that the diffusion was a slower type of penetration than the permeability type of penetration. This you might possibly expect since the material had only gases and a small amount of moisture in the interstices at the start of the cook. It seems that the liquid which was in the chip prior to penetration slowed down the penetration rate.

Dr. Aiken: Rouse has shown recently that the relative humidity with which a point within a hydrophobic film, such as polyethylene, is in equilibrium varies uniformly across the thickness of the film. That is, if one side of this film is in equilibrium with 100% R. H. and the other side is in equilibrium with 0% R. H., the center of the film will be in equilibrium with 50% R. H. Rouse found, however, that in a hydrophilic film, such as Nylon, the greater portion of the film is in equilibrium with a much higher relative humidity than the average of the relative humidity on the two sides of the sheet.

Mr. Yundt: As I recall, there has been some mention that, at these high relative humidities, condensation takes place in the capillaries. Then you can have transfer of liquid water along the capillaries which will take place more rapidly than simple vapor diffusion. If you have 100% humidity on one surface, you will have condensation in the capillaries.

Dr. Stamm: Yes, I did not get the picture. That is

the case where you have hydroscopic material. An interesting paper by Fourt and Harris recently gave us the same sort of thing.

Dr. Aiken: In the case of cellophane or vinyl film, I wonder if diffusion is not more through momentary openings in regions not so crystalline resulting from movement of molecules with passage of water vapor through temporary openings that might not have been there when the sheet was made. Regenerated cellulose is extremely permeable to passage of water and is resistant to passage of gas.

Dr. Shaw: We made a number of measurements of permeability on different plastics, using water and also a whole series of organic solvents. By the way, we expressed our results in resistance rather than permeability. The film showed marked resistance to the solvents which had no action on it. With materials for which the solvents might have some swelling action, the vapor passage was greater or the film resistance was less.

Mr. Yundt: Concerning the capillaries of regenerated cellulose, which are opened up by moisture, I do not think that it is necessary to postulate them. One substitute for a steam trap to remove water from steam lines is a simple orifice. At a given pressure differential, many times the weight of water can be forced through than weight of steam. When there is no longer any water, steam flows through, but not much steam is lost in terms of pounds per hour. Analogously, if we have 100% relative humidity on one side of a cellulose membrane, there will be condensation in the capillaries, and the water will move through in the form of liquid until it comes close to the opposite side of the sheet. There revaporization and diffusion will take place, because you have a low relative humidity or vapor pressure at that point. The liquid in the capillaries once again becomes a vapor and moves through by vapor diffusion. Therefore, you would expect to have a very high moisture content across the major portion of the sheet, and then you would expect the moisture content to fall to practically zero as you approach the zero relative humidity side of the sheet, as Dr. Aiken has indicated it does.

Dr. Aiken: What has been considered in many cases vapor diffusion may be both vapor diffusion and liquid diffusion.

The Swelling and Shrinking of Wood, Paper, and Cotton Textiles and Their Control

H. TARKOW

Wood, paper, and cotton have hygroscopic components which are responsible for their dimensional instability. The basic structural unit in each is the plant fiber. There has been considerable discussion on the microscopic structure of the fiber. It is generally agreed that it consists of the following elements: a primary wall composed essentially of cellulose fibrils whose orientation is at some large angle to the fiber axis; a relatively thin layer or "wrapping" of cellulose fibrils whose orientation is also at some large angle to the fiber axis; a relatively thick layer in which the orientation of the fibrils is at some small angle to the fiber axis; a relatively thin layer in which the orientation of the fibrils is at some large angle to the fiber axis; and, finally, the lumen. The presence of the thin layer adjacent to the lumen in wood has been claimed by Bailey and Kerr (*2*) on the basis of optical studies. The first direct evidence of the existence of such a layer was presented recently by Pearson (*9*). Figure 1 shows one of his microphotographs in which the peculiar orientation of the layer adjacent to the lumen is clearly visible.

In general, the water-swollen volume that plant fibers attain after drying and rewetting does not exceed the original volume of the fibers as they existed in the living plant. This is true because the anatomical features of such fibers are developed in the presence of free water. The extent of swelling that the fibers undergo is fixed by the "hoop tension" developed in the outer wrapping and in the primary wall. It will be shown that the presence of such restraints to unlimited swelling, including that due to the presence of the inner layer of the secondary wall, provides a general method for controlling the dimensional changes of materials composed of plant fibers.

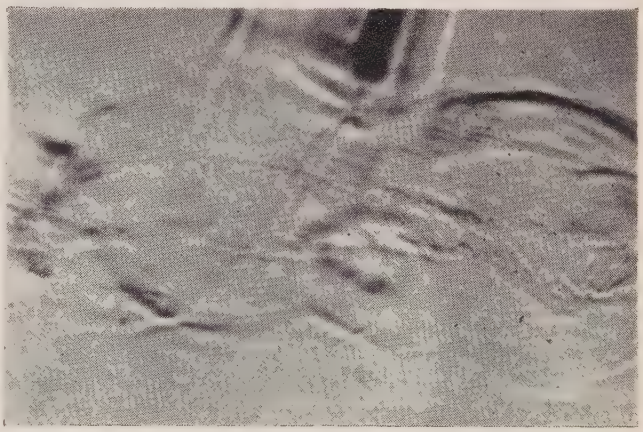

Fig. 1. Oriented structure of lumen wall of a wood fiber. Photomicrograph by Pearson

H. Tarkow, Chemist, Forest Products Laboratory, maintained at Madison, Wis., in cooperation with the University of Wisconsin, Forest Service, U. S. Department of Agriculture.

SORPTION PHENOMENA

In connection with the swelling of wood, paper, and cotton textiles in water, it is of interest to consider briefly the uptake of moisture by these materials. The full line in Fig. 2 represents the adsorption isotherm for water on Sitka spruce (*1*). The remarks made about spruce hold equally well for cotton. The shape of the isotherm is common. For example, benzene on ferric oxide gel, bromine on silica gel, nitrogen on paper, argon on zinc oxide, and even water on sulphuric acid are represented by sigmoid-shaped curves. Although much work has been done in the field of adsorption, the entire adsorption isotherm is still not understood. Attempts have been made to rationalize portions of the curve.

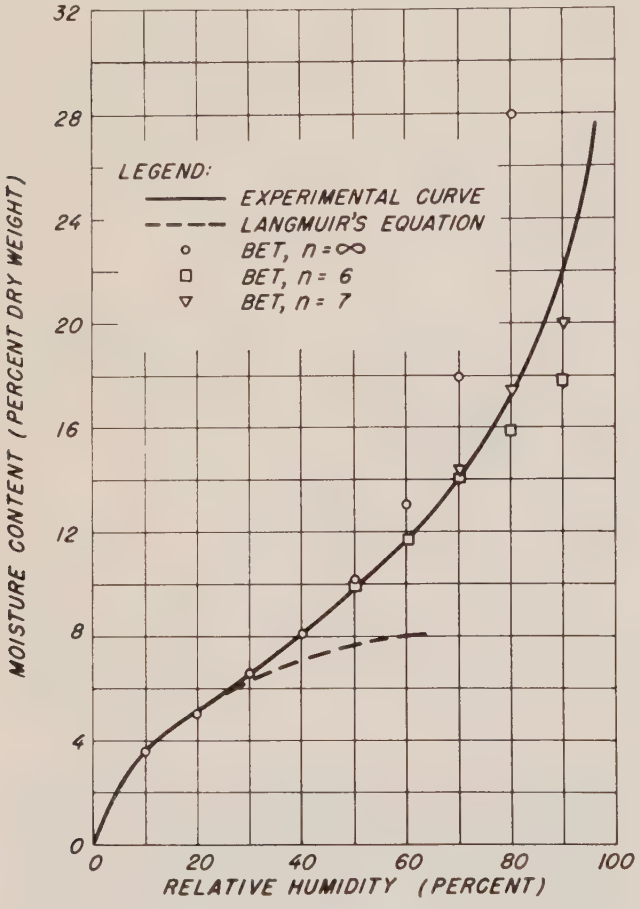

Fig. 2. Adsorption isotherm for spruce wood

The Langmuir theory of unimolecular adsorption has been used with success in correlating data of some systems. The broken curve in Fig. 2 was obtained by using Langmuir's equation. The theoretical curve is in agreement with the experimental curve only to 20% relative humidity, beyond which deviations become marked. Many investigators have interpreted such behavior by assuming two adsorption mechanisms: (1) unimolecular adsorption at low relative humidities, followed by (2) capillary condensation at higher humidities. In porous solids, such as silica gel, there are undoubtedly voids, in which capillary condensation can conceivably occur; that is, at a given relative humidity, all capillaries of radius less than a certain value fill up and those with larger radii remain empty. Such a theory was first proposed in 1911. Today thirty-seven years later, it is still a question of much debate as to how great a role should be assigned to capillary condensation. One reason for this is the great difficulty in confirming the Kelvin equation for the condensation of liquids in capillaries of radius less than 1 micron.

With swelling gels, such as the materials here discussed, there is further theoretical difficulty when an attempt is made to introduce the theory of capillary condensation. The oven-dry cell walls of plant tissues are generally believed to have very little submicroscopic void volume. Capillary condensation would hence have to occur through the action of water in wedging apart the potential swelling units, thereby creating a capillary system. Thermodynamically, this is unsound, for water in such capillaries would be under very high tension and would tend to collapse the capillaries. In a system of rigid capillaries, such as silica gel, it is conceivable that capillary condensation could occur, for here the rigidity of the capillary walls is great enough to oppose the tension in the water tending to collapse the capillaries.

A recent theory by Brunauer, Emmett, and Teller (*4*) (hereafter abbreviated as BET), called the theory of multimolecular adsorption, has shown much promise in providing an understanding of large sections of adsorption isotherms for adsorbents having rigid submicroscopic capillaries. It assumes that, when a vapor comes in contact with an adsorbent, a portion of the vapor condenses on some of the bare surface, liberating a heat of adsorption; a second portion condenses on part of the first layer, liberating a smaller heat of condensation; a third portion condenses on a portion of the second layer, again liberating the same smaller heat of condensation, and this process is repeated up to an infinite number of layers. The adsorption on a given layer is treated as a separate Langmuir adsorption. On summing up the separate adsorptions, BET arrive at an equation expressing adsorption in terms of the relative vapor pressure, the surface area of the adsorbent, and the net heat of adsorption of the first layer. The possibility of capillary condensation in the Kelvin sense is not considered. On plotting the adsorption data in a certain manner, a linear relationship is obtained from whose slope and intercept the surface area of the adsorbent and the net heat of adsorption of the first layer can be calculated.

Babbitt (*1*) has attempted to evaluate the theory for water on cotton and on wood. In Fig. 2, the circles represent the predicted adsorption values. The validity of the theory extends from below 10% to only 50% relative humidity. In their original work, BET realized that in most adsorbents, such as solid catalysts, the number of layers over the adsorbent cannot be infinite because of the likely adsorption in submicroscopic capillaries which would limit the number of layers. They introduced a constant n, which they interpreted as being the average number of layers over the adsorbent. In Fig. 2 are given the predicted adsorption values for $n = \infty$, 7, and 6. With $n = 7$, the agreement with the observed values is good up to 80% relative humidity. The good correlation of the adsorption data below 80% relative

humidity is in itself not sufficient proof of the validity of the BET theory for it should be realized that the equation contains four constants which should permit empirical representation of the data. Even the simple BET theory, valid to 50% relative humidity, has three constants. An evaluation of the theory would require a comparison of the heat of adsorption and the surface area as predicted by the BET theory with the corresponding values obtained by other accepted methods. Babbitt has calculated the net heat of adsorption of the first water on cotton and wood. He finds a value of 80 calories per gram of water; the observed value is 280 calories. The agreement is poor.

Concerning the surface area as determined by the theory, the same disturbing feature found in the theory of capillary condensation is encountered. The BET theory was developed on the assumption that, at any given vapor pressure, the amount adsorbed is directly proportional to the specific surface area of the adsorbent; that is, the entire surface area is available at the onset of adsorption. In swelling gels, such as cellulose and wood, the surface area develops progressively with adsorption. With water on silica gel, since the entire surface area is available at the onset of adsorption, the BET plot extending only to 50% relative humidity is capable of supplying the surface area. With cellulose, not all of the potentially available area has been made available even at 50% relative humidity.

Recently, Hermans (*8*) has revived an old theory of adsorption. He believes that adsorption is due to the formation of two hydrates by the cellulose in the amorphous regions. Hermans submits x ray evidence that one of the interplanar distances increases when regenerated cellulose is exposed to water vapor. Furthermore, he believes that the similarity of isotherms in the sulphuric acid-water system and the cotton-water system is indicative of hydrate formation since the acid is known to form hydrates. The increase in spacing is only 0.5 A. This is undoubtedly too small to accommodate a water molecule; the change, furthermore, is gradual. It may be that what Hermans observed was not due to the formation of hydrate but to a change in crystalline form of cellulose as catalyzed by water. The similarity of the cellulose-water isotherm with that of the acid-water isotherm is not necessarily an indication of the formation of hydrates. The adsorption isotherm of argon on zinc oxide is sigmoid in form. Chemical interaction here is highly improbable.

SWELLING AND MOISTURE GAIN

A full understanding of the adsorption isotherm is, obviously, yet to be obtained. However, regardless of the ways by which water is held by cellulose or wood, the fact remains that adsorption is accompanied by swelling. The relationship between adsorption and swelling of cellulosic materials has been extensively studied. Many find a deviation between the sum of the individual volumes of water and cellulose and the total volume. Some attribute this deviation to the compression of the initially adsorbed water (*5*). On the other hand, Hermans (*8*), who finds the deviation with regenerated cellulose, attributes it to the existence of submicroscopic voids into which moisture can enter without contributing to the total volume.

Eyring (*6*) has reviewed the evidence for the existence of the deviation. He concludes that, whether the density of the initially adsorbed water is high because of adsorption compression or whether the density is apparently high because of the existence of voids, the effect is small and that to a first approximation, it can be assumed that water on being adsorbed on cellulose or wood contributes its normal volume to that of the adsorbent.

SWELLING OF WOOD

Consider a volume of wood. If the water-wood volume relationship is truly an additive one and if the size of the cavities of the tracheids, wood fibers, and vessels remains constant during addition or removal of water, then it can be shown (*15*) that the percentage external volumetric shrinkage from the

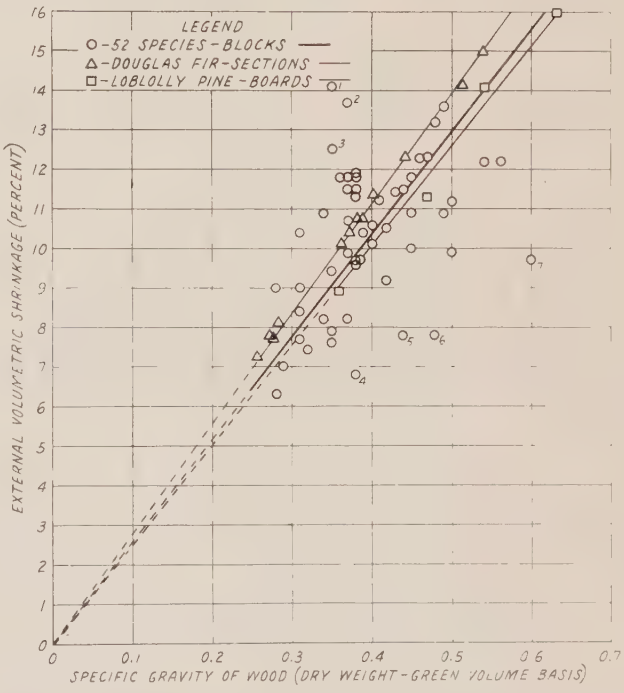

Fig. 3. Relationship between specific gravity of wood and the external volumetric shrinkage

fully swollen to the oven-dry condition is equal to

$$S = d_w f V_s \qquad (1)$$

where d_w is the oven-dry weight water-swollen volume density, f is the fiber-saturation point, and V_s is the specific volume of the water considered as a first approximation equal to unity. If the assumptions are correct, then on plotting S against d_w for different species of wood, a straight line should be obtained passing through the origin. Figure 3 shows such a plot. The relationship is approximately linear. The points falling appreciably below the curve represent species having high water-soluble extractive contents. Owing to the phenomenon of bulking, which will be discussed later, the shrinkage of these species is abnormally low. The points that lie appreciably above the curve represent species where undoubtedly some change in cavity dimensions occurs during swelling

or shrinking. That most of the points lie close to the curve substantiates the validity of the two assumptions made in deriving equation (1).

The assumption pertaining to the constancy of the cavity diameters may be surprising, especially if it is realized that a hole cut in a disk of gelatin gel swells as much in water as the piece cut from it. That is, the hole gets larger. Gelatin, however, is an isotropic material having no restraints to unlimited swelling; whereas wood is highly anisotropic. The cell walls, it will be recalled, contain relatively thin outer and inner layers of cellulose in which the orientation of the crystallites is approximately at right angles to the longitudinal axis. The constancy of the fiber diameters must be due especially to the presence of the inner layer in the secondary zone. A decrease in fiber diameter could only occur by buckling of the inner layer. This is never observed when water is the swelling agent. An increase in fiber diameter would require stretching the layer circumferentially. This is opposed by the peculiar orientation of the fibrils.

Stamm has shown from permeability studies (*10*) that the fiber cavities of softwoods do not change in dimensions as the wood is exposed to relative humidities ranging from 95 to 0%. More recently the behavior of individual vessels, tracheids, and resin canals in cross sections of wood has been observed microscopically as the sections were exposed to relative humidities between 20 and 95%. Within the accuracy of the measurements, the tracheids and vessels were found to show no change in dimensions. The resin canals, on the other hand, did enlarge on swelling. Unlike the cavities of tracheids and vessels which are bounded by cell walls having the previously described cell-wall structure, resin canals are bounded by several other cell elements. They have no cell walls of their own; in fact, they correspond to a hole drilled in a piece of wood. Such a hole, on swelling, increases in dimensions by the same amount as the disk cut to make the hole. The swelling of the resin canals is thus similar to the enlargement of a hole in a sheet of gelatin gel. The total volume of the resin canals, however, is relatively small and, hence, the assumption concerning the constancy in size of the fiber cavities is approximately valid.

If the swelling of wood is restrained by clamping, three things may happen. Some swelling may occur inwardly; that is, the lumen wall may buckle. Secondly, increased swelling may occur externally in another direction; that is, if tangential swelling is restrained, the radial swelling may be enhanced. Thirdly, the equilibrium moisture content may be reduced. Barkas (*3*) has shown that if wood conditioned at some relative humidity is subjected to a compressive load, the relative humidity of the moisture in the wood increases, and the wood loses moisture.

In general, the volume change that occurs in wood during adsorption or desorption is due only to the addition or removal of moisture from the cell walls.

SWELLING OF FABRICS

A single cotton fiber exposed to water vapor swells in diameter and, on drying, shrinks in diameter. The length remains approximately constant. If the fiber is moistened while stretched and then dried under tension, a strain is fixed in the fiber. On remoistening and drying without tension, the strain is removed, resulting in an apparent shrinkage. Since most spinning operations are carried out at high relative humidities, such strains are present in yarns and fabrics and are responsible for some of the shrinkage on laundering. The effect, however, is relatively small, perhaps 1%.

It should be noted that the dimension change here is not due to swelling of the fiber; it is due to relaxation. Suppose the fibers are spun into yarn having a certain amount of twist and compaction. When exposed to some high relative humidity, the cell walls swell and the fibers increase in diameter. If the yarn is not compact, the yarn diameter can remain constant in size because the fibers swell into the interfiber space. With increasing compactness, the amount of such inward swelling is reduced and the yarn diameter increases; that is, more and more of the swelling is transmitted to the external dimensions. If the degree of twist remains constant, a decrease must occur in the length of the yarn to permit the fibers to go around the cylinder of yarn of increased diameter. The amount of such shrinkage due purely to the swelling of the fiber is, however, small. On complete immersion in water, as in laundering, in addition to swelling of the cell walls of the fibers, there occurs a movement of the fibers with respect to each other due to the tendency of the water to partially disperse the fibers. This, too, results in a further increase in yarn diameter, with corresponding shrinkage of the yarn in length. Any factor, such as agitation or the presence of a wetting agent, that tends to increase the penetration of the water between the fibers increases the magnitude of this shrinkage.

If the yarn is woven into cloth, the fabric, on immersion in water, undergoes appreciable shrinkage. This is due to the combination of two effects. First, there is the shrinkage of the yarn in length, as already described. Much more important is the effect of the fabric construction. As the diameter of the yarn, say the weft threads, increases, the crimp of the warp thread tends to increase; in order to increase, however, the warp thread must get longer. This is very difficult. The only alternative is for the weft threads to come closer together. The fabric shrinks warpwise by an amount depending on the fabric construction. It may be as much as 10%.

Thus, primarily because of the partial dispersion of the fibers and secondarily because of the swelling of the cell walls, the yarn diameter increases and the fabric shrinks. The extent of shrinkage on thorough wetting can be somewhat reduced by modifying the fabric construction. Sizing agents, such as starch, can also reduce the effect by binding together the yarns and the fibers. The stabilization is not permanent. Furthermore, the texture and "hand" of the fabrics are undesirably changed. Application of a water-repellent finish is also of little value, for, under hydrostatic head, water is able to penetrate the cloth.

The application of a small amount of water-soluble resin, followed by thermal condensation, is an effective way of reducing shrinkage on laundering. The process

was first developed by Broadhurst, Tootal Lee and Company in 1930. Since that time about 150 patents have been granted in England for what appear to be modifications of the original patent. Melamine resins are especially useful. Thus, for a lightweight cotton sheeting undergoing a shrinkage in water of 6.7%, if 5% of resin is properly introduced, the shrinkage of the cloth on washing is reduced by 80%. That the effect is not due to reduced swelling of the cell walls is shown by the fact that the hygroscopicity of the treated fabric is not much different from that of untreated fabric. The beneficial effect is believed to be due to the reduced fiber-dispersion effect brought about by occasional bonding together of fibers by resin—in effect, a vulcanization of fibers. That is, the amount of water that can be accommodated between fibers is reduced, resulting in a reduction in the extent to which the yarn diameter is increased. Such treated cloth has a reduced imbibed-water content as determined by centrifuging the water-logged fabric.

SWELLING OF PAPER

Paper, too, responds to changes in relative humidity. As with fabrics, the total true swelling is not transmitted to the external dimensions, for some of the swelling occurs in the interfiber spaces or in what the paper technologist calls the pores. The swelling that is transmitted to the external dimensions gives rise to what The Institute of Paper Chemistry calls hygroexpansivity. It is a relatively small effect and not very serious for most uses. There are some instances, however, where close dimensional control is necessary, for example, machine-sorted classification cards and lithograph and map papers.

Perhaps the most serious consequence of the action of water on paper is the reduction in mechanical properties. This is generally believed to be due to the effect of water on those interfiber bonds which were created when the wet fibers were initially dried on the paper machine. The effect is reversible; on redrying, the dry strength is regained.

The incorporation of a small amount of resin has an appreciable effect on the properties of the wet paper. As with fabric, the resin simply provides for increased fiber-to-fiber bonding with a water-insoluble material. Again the fibers are, in effect, vulcanized. Dry strength is not adversely affected, provided the resin content does not exceed a few per cent, and the wet strength is improved several fold. The hygroscopicity of such paper is only slightly reduced; thus the treatment does not alter significantly the true swelling of the fibers. The amount of inbibed water—that is, the amount of water that can be accommodated in the interfiber spaces alone—is appreciably reduced.

DIMENSION STABILIZATION OF WOOD

With wood, the picture is different. In the first place, there is no interfiber movement as occurs in paper and fabric, for the fibers are bonded together by the intercellular material; that is, by the middle lamella. In fact, the small amount of resin in resin-treated fabric may be considered to function in the same manner as does the intercellular material in wood; that is, it reduces interfiber movement. In wood, such movement is completely absent. In the second place, since there is no free interfiber space in wood and since it has been shown that the fiber cavities of wood do not change in size during swelling, the entire swelling of the cell walls is transmitted to the external dimensions. That is, as a first approximation, for every unit volume of water vapor adsorbed, the external volume of the wood increases by unit volume. In resin-treated paper and fabric, although interfiber movement has been reduced, the existence of voids between the fibers enables the normal swelling of the cell walls to occur, in some measure, within these voids.

Resin Treatment

Since there can be no interfiber movement in wood, small amounts of resin should be without effect in stabilizing the dimensions of wood. In fact, to reduce the swelling and shrinking tendency of wood by 70% requires about 30% of phenolic resin (*11*). The wood, after treatment, is found to be permanently swollen, or bulked out, and presumably by an amount depending on the amount of resin present in the cell walls. Any resin deposited in the coarse capillaries will not contribute to the permanent swelling. By observing certain precautions, it is possible to impregnate wood so that most of the resin is present in the cell walls or the wood gel. Since wood can be considered to be a limited-swelling gel, it can be assumed that, if something other than water is deposited in the cell walls, the resulting treated wood will swell in water to the same dimensions that the untreated wood would swell in water. That is to say, the volume of deposited material plus water adsorbed in the cell walls is constant; the greater the volume of resin in the cell walls, the smaller is the volume of water that can be adsorbed and, therefore, the smaller is the amount of swelling in water. It should be possible to calculate the extent of bulking and, therefore, the extent to which swelling in water is reduced, if the following assumptions are made:

1. The fiber saturation point of wood is 29% (*12*).
2. All of the added resin is present in the cell walls where it can contribute to the bulking out of the cell walls.

With these assumptions, the following equation was derived for the per cent reduction in swelling and shrinking tendency—*A*,

$$A = \left[1 - \frac{\dfrac{100/d + 29}{100/d + V_s X} - 1}{\dfrac{29d}{100}} \right] 100 \qquad (2)$$

where d is the oven-dry density of the untreated wood, V_s is the specific volume of the bulking agent (namely, the resin) and X is the amount of bulking material expressed as a weight percentage of the original wood.

Let us now calculate A for wood having an oven-dry density of 0.5 gram per cc. which has been treated so as to attain a resin content of 30%. V_s for phenolic resin is 0.78 cc. per gram. Substituting in equation (2), a value of 83% is obtained for A. The experimentally observed reduction in swelling tendency is 70 to 75%. Actually, the calculated value should be somewhat lower than 83%, for it was assumed, above,

that all of the resin is present in the cell walls. Some, however, will be present in the coarse capillaries where it cannot contribute to the bulking of the cell walls and therefore cannot contribute to reducing the swelling tendency.

Thus, without making any assumption regarding interaction of the resin with the wood, but assuming only that the resin acts in a purely mechanical way as a bulking agent, it is possible to calculate the magnitude of the reduction in swelling in water after treating wood with resin. It becomes apparent why the low percentage of resin in treated paper and fabric has so little effect on the hygroscopicity, or true swelling, of the cell walls. The extent to which the cell walls are bulked out is very small.

Acetylation

In recent years, work at the Forest Products Labo-

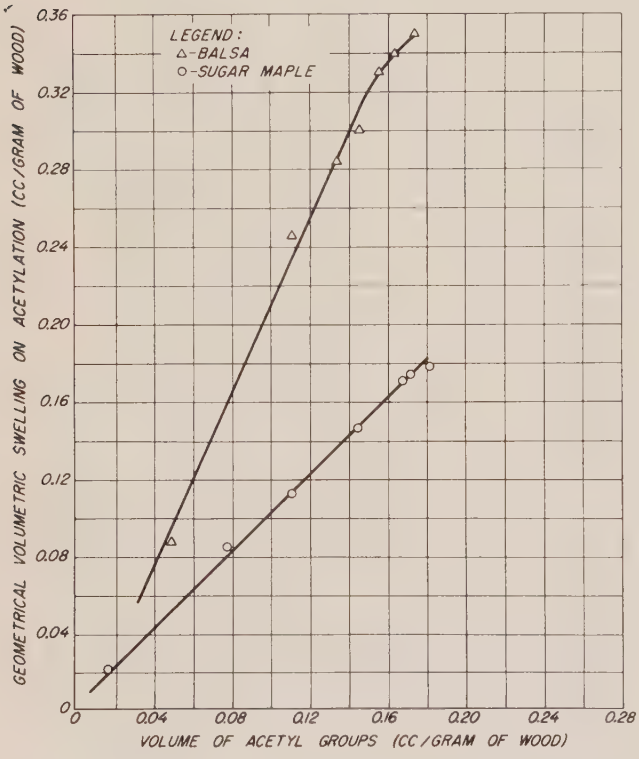

Fig. 4. Relationship between the volume of acetal groups added to wood and the resulting geometrical volumetric swelling

ratory has shown how to acetylate wood without degrading it (*13*). Acetyl contents of the order of 20% (dry wood weight basis) are sufficient to reduce the swelling tendency by 60 to 75%. An interesting finding is the fact that the volume relations of the system wood–acetyl (CH_3CO) are similar to that of the system wood–water.

Figure 4 shows the relationship between the volume of acetyl groups placed in 1 gram of wood and the corresponding observed volume change of the wood. The curve for maple is typical of that obtained for many species of normal density. The slope is unity, which means that, for each volume of acetyl groups placed in the cell walls, the external volume of the wood increases by unit volume. Thus, for many species, the acetyl groups add their volume to that of the wood. The fiber cavities must remain constant in size.

The curve for balsa is unusual. This balsa has the extremely low density of 0.1 gram per cc. Note that, on acetylation, the external volume increases by about two unit volumes for every unit volume of acetyl group added. Such a relationship is also obtained with water and balsa. For every volume of water adsorbed by balsa of density 0.1 gram per cc., the external volume increases by two volumes. There is no satisfactory explanation for this behavior. An outer wrapping similar to that present in normal fibers has not been observed in isolated balsa fibers. The abnormal volume relationships in balsa may be due to slight changes in the dimension of the fiber cavities during sorption. Calculations show that the changes in cavity diameter need be as small as $^1/_2$ micron to produce the observed external volume effect.

The water-swollen dimensions of acetylated wood are the same as those of the corresponding untreated wood. This suggests a similarity between resin-treated wood and acetylated wood in the mechanism whereby the hygroscopicity is reduced; consequently, it is of interest to see whether equation (2) can be used to calculate the per cent reduction in swelling tendency of wood after acetylation. The specific volume of the acetyl group is taken as 0.902 cc. per gram. Calculations were made for maple having a density of 0.68 gram per cc. Table I presents the observed reductions in swelling tendency together with the calculated reductions.

Table I. Comparison of Observed and Calculated Reductions in Swelling Tendency of Acetylated Maple

Acetyl content, %	*Calculated A,[a] %*	*Observed A,[a] %*
8	27	25
12	40	39
15	53	51
18	61	63
21	70	73

[a] Percentage reduction in swelling and shrinking tendency.

One might suppose that the reduction in hygroscopicity and swelling tendency is due to the elimination of hydrophilic hydroxyl groups; however, the successful use of equation (2) shows that the removal of hydroxyl groups is only incidental to the dimensional stabilization and not the cause of stabilization. Further evidence of this was obtained from studies involving the butyrylation of wood.

Assume two pieces of wood, each weighing 100 grams, to one of which is added 20 grams of acetyl groups and to the other, 20 grams of butyryl groups. If reduction in hygroscopicity or swelling tendency on acylation is due to the elimination of hydroxyl groups, the acetylated wood should swell less in water than does the butyrylated wood because of the greater number of hydroxyl groups that have been replaced by acetylation. On the other hand, if the reduction of swelling tendency is due simply to a bulking action, then both specimens should have about the same reduced hygroscopicity, or reduced swelling capacity, because the volume of 20 grams of acetyl is about the same as the volume of 20 grams of butyryl; that is, both bulk the cell walls to about the same extent.

Actually the reductions in swelling tendency of both are observed to be about the same. In fact, if comparison be made of specimens having not the same weight of acetyl and butyryl groups, but having the same volume, then within experimental error, the reductions in swelling tendency are the same (Fig. 5). Thus it would seem that the only function of the acyl group is to act as a bulking agent. If it were possible to introduce the stearoyl group to the extent of about 20%, the swelling capacity of the wood presumably would be reduced to the same extent as that in acetylated wood having the same acyl content, even though with the stearoylated wood only a very small percentage of the hydroxyl groups would have been replaced. The basic assumption in the above theory is that, regardless of the acyl content or the nature of the acyl group, for a given weight of wood,

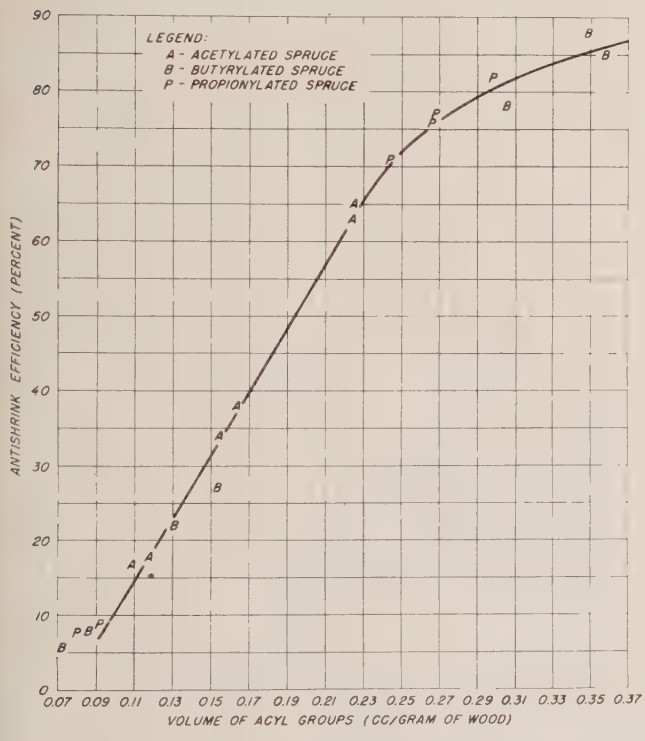

Fig. 5. Relationship between volume of acyl groups added to wood and the resulting antishrink efficiency

the sum of the volume of the acyl groups added to the cell walls and the volume of the water adsorbed by the cell walls remains constant.

Table II. Hygroscopicity of Esterified Pulp

Ester group	*Replacement of hydroxyl groups, %*	*Ester content, %*	*Hygroscopicity at 90% relative humidity, %*
Acetyl	21.2	14.50	17.5
Butyryl	22.2	22.95	6.1
Stearoyl	21.7	51.50	4.0

A great deal of work has been done recently at The Institute of Paper Chemistry on the properties of acylated pulp and sheets made from these pulps. It is of interest to examine the data in terms of the bulking theory. Harrison (7) acetylated, butyrylated, and stearoylated a Mitscherlich pulp by the "fibrous acylation" technique. On comparing the hygroscopicity of the modified pulps containing the different acyl groups but which were esterified to the same degree (that is, same percentage replacement of hydroxyl groups), he found that the hygroscopicity decreased with increasing length of the acyl group. Some of his data are presented in Table II.

Harrison attributed the definite trend in hygroscopicity to the increasing hydrophobic character of the acyl chain with increasing length. In Table III are presented Harrison's data in a slightly modified form. Whereas in Table II the percentages are expressed on the basis of total weight, in Table III the percentages are expressed on the basis of the weight of dry, untreated pulp.

Table III. Hygroscopicity of Esterified Pulp

Ester group	*Ester content, g. per 100 g. pulp*	*Volume of ester group, cc.*	*Volume of water, cc. per 100 g. pulp*	*Ester volume plus water volume*
(1)	(2)	(3)	(4)	(5)
Acetyl	16.95	15.3	24.8	40.1
Butyryl	29.90	31.6	8.4	40.0
Stearoyl	106.0	115	8.6	124

In the acetate, 100 grams of pulp are combined with 16.95 grams of acetyl groups; or, considering the specific volume of acetyl, 100 grams of pulp are combined with 15.3 cc. of acetyl groups. At 90% relative humidity, 24.8 grams of moisture are adsorbed. Assuming no adsorption compression of the water, the total swelling of the 100 grams of pulp on acetylation and exposure to 90% relative humidity is 15.3 plus 24.8, or 40.1 cc.

In the butyrate, 100 grams of pulp are combined with 29.90 grams, or with 31.6 cc. of butyryl groups. The specific volume of the butyryl group is 1.055 cc. per gram. The moisture gain is 8.4 grams. The total swelling of the 100 grams of pulp on butyrylation and exposure to 90% relative humidity is 31.6 plus 8.4, or 40.0 cc. This agrees well with the total swelling observed with the acetylated pulp. Thus, the smaller hygroscopicity of the butyrylated pulp is not due to an increased hydrophobicity but to the fact that there is a greater volume of acyl group in the cell walls than there is in the cell walls of the acetylated pulp.

As for the stearate, in column 5 of Table III it is shown that the sum of the volume of the stearoyl groups and the volume of the adsorbed water is much greater than that in the other esterified pulps. Harrison states that the stearoyl values are too high and calls them "apparent" values. Thus the volume of the stearoyl groups in the cell walls should really be less than that given in column 3 of Table III. This, of course, would reduce the sum of the volumes given in column 5. It is not believed, however, that if this correction could be made the total swelling would be reduced to 40 cc. There is still another factor responsible for the large swollen volume of the cell walls in the stearoylated pulp.

Implied in the bulking theory is the assumption that the maximum volume of acyl groups that the cell walls can accommodate cannot exceed the swelling of the untreated fiber at the fiber-saturation point, where

further swelling is prevented by the restraining walls surrounding the central zone of the secondary wall. Suppose the pulp is made to react with more than this volume of acyl groups. Something has to give. The restraining walls rupture and the cell walls no longer function as a gel of limited swelling capacity; that is, the constancy of the sum of the volumes of acyl groups and water can no longer be assumed to hold. The volume of stearoyl groups added to 100 grams of pulp is about 115 cc. (col 3, Table III). There is no question but that this volume of stearoyl groups exceeds the volume of water adsorbed by 100 grams of pulp.

Similar calculations can be made for acylated pulps in which the volume of the acyl group is not large enough to rupture the restraining walls. In Table IV, prepared from Harrison's data, are presented the acyl contents required to reduce the hygroscopicity of pulp by 25%.

Table IV. Acyl Content Required to Reduce Hygroscopicity of Pulp by 20%

Acyl group	*Acyl content, weight % of pulp*	*Volume of acyl group, cc. per 100*	*Hydroxyls replaced, % of total number*	*Reduction in hygroscopicity, %*
Acetyl	22.3	20.1	28.0	25
Butyryl	16.3	17.2	12.4	25
Stearoyl	17.3	19.5	3.5	25

The volume of the different acyl groups required to be introduced in 100 grams of pulp to reduce the hygroscopicity by 25% (Table IV) is approximately the same. Such a reduction in hygroscopicity is obtained when 28% of the hydroxyl groups is replaced by acetyl groups or when only 3.5% of the hydroxyl groups is replaced by stearoyl groups. Thus, provided the degree of acylation is not too great—less than 30% on the basis of the untreated pulp—the effect of such treatment on the hygroscopicity can be quantitatively explained on the basis of the bulking theory; that is, on the basis that the only function of the acyl group is to displace an equal volume of the water that would normally be adsorbed.

For the sheets listed on Table III, the hygroexpansivity for acyl groups with increasing lengths is 0.395, 0.175, and 0.115%, respectively. Harrison attributes this trend to the formation of voids during esterification into which some of the swelling can occur without being transmitted to the external dimensions. As already shown, esterified pulps have reduced hygroscopicity because of the displacement of adsorbed water by the acyl groups. Assuming that the hygroexpansivity is proportional to the amount of water adsorbed, the ratio of hygroexpansivity to hygroscopicity should be constant. The calculated values are 0.022, 0.029, and 0.029 for the acetate, butyrate, and stearate, respectively. These values are reasonably constant. Thus it would seem that the hygroexpansivity is reduced with increasing length of acyl chain (but constant percentage of hydroxyl replacement) not because of the formation of voids but because the amount of water that is adsorbed is reduced.

Formaldehyde Treatment

Since the reduction in swelling tendency by the bulking method is essentially mechanical in its mechanism, anything that can be placed in the cell walls should be effective, provided the substance deposited is water-insoluble and nonvolatile, for otherwise it would soon be removed from the cell walls. Stamm (*14*) has shown that the dimensions of wood can be stabilized by depositing sugar, or even salts in the cell wall. These materials, however, are readily leached out and therefore the effect is not permanent.

Stabilization of wood by the bulking method requires relatively large quantities of chemicals. Other methods were sought that would consume less chemical. The possibility of forming cross links between swelling units was considered. Early work of Staudinger has shown the profound effect of small quantities of divinyl benzene during the polymerization of vinyl benzene on the swelling properties of the resulting polymers.

The reaction of fabrics and paper with aqueous formaldehyde has been studied by many investigators. As with resin treatment, reaction with formalin results in reduced shrinkage of fabrics on immersion in water, and in improved wet burst strength of paper. The treatment does not significantly alter the swelling of the cell walls. Thus it would seem that the effect is due to the occasional cementing together of fibers by, presumably, polymerized formaldehyde. The treatment is not new. It was first publicized in the patent literature about 40 years ago, yet it has not been used commercially. The main reason for its nonuse is that it requires an acid catalyst, which, besides promoting the desirable reaction between formaldehyde and cellulose, also degrades the material.

Wood, on treatment with slightly acidified formalin, attains very little dimensional stability. If, however, the wood is treated with formaldehyde vapor under slightly acid conditions, considerable dimensional stabilization is obtained. In fact, with an uptake of formaldehyde of only a few per cent, the swelling and shrinking tendency can be reduced by 70%; that is, the hygroscopicity of the cell walls can be reduced by 70%. The effect is obtained essentially by a reduction in water-swollen volume, showing that the mechanism of stabilization is different from that of the bulking method. The presence of an acid catalyst, however, results in severe losses in mechanical properties of the wood.

It is interesting, however, that the wood must be treated with the vapor rather than with aqueous formaldehyde to achieve the high degree of stabilization. It is believed that methylene cross linkages are produced between swelling units of wood through an acetal type of reaction. Consideration of the structure of the carbohydrates suggests that it is unlikely that acetal formation occurs between hydroxyl groups on the same glucose residue. The formation of cross linkages presumably requires a certain spatial relationship of the pair of hydroxyl groups involved in the acetalization. If the wood is fully swollen, these hydroxyl groups are too far apart to react with the formaldehyde. Since aqueous formaldehyde is an excellent swelling agent for wood, it is not surprising that cross linking does not occur when wood is treated with formalin. Formaldehyde vapor, on the other hand, is a poor swelling agent; consequently, the spa-

tial arrangement of the hydroxyl groups remains favorable for the reaction. Incidentally, since stabilization is obtained without the need of preswelling, it follows that the formaldehyde reacts with hydroxyl groups that are in highly accessible regions of the wood.

The following indirect evidence further suggests that stabilization results from the formation of cross linkages:

1. A small amount of formaldehyde uptake is sufficient to impart a high degree of stabilization.
2. Unlike the dimensional stabilization obtained by treating wood with bulking agents where the water-swollen dimensions are not altered but where the oven-dry dimensions are greatly increased, stabilization by formaldehyde treatment results in greatly reduced water-swollen dimensions. The treatment apparently adds additional restraints to the swelling by linking together swelling units which normally become widely separated during swelling.
3. If cross linkages are formed, then not only should the swelling in water be reduced, but also the swelling in such good wood-swelling liquids as aqueous sodium hydroxide, pyridine, and morpholine. This is found to be true.
4. If methylene linkages are formed, these must be acetal in character and should hydrolyze in acid solution. On immersing formaldehyde-stabilized wood in concentrated hydrochloric acid, the wood slowly swells and finally reaches the same swollen dimensions that untreated wood reaches. Thus the cross linkages are unstable in acid (although stable in alkali). Acetal linkages are known to have these properties.

Thus, from several considerations, it seems that dimensional stabilization of wood by formaldehyde vapor is due to the formation of occasional links between submicroscopic swelling units in the cell walls. The need of an acid catalyst, however, places definite limitations on the use of the reaction.

Heat Treatment

It has long been recognized that heat treatment of cellulosic materials results in reduced hygroscopicity. It has been suggested that heating produces a rearrangement of the amorphous region resulting in increased hydrogen bonding, and that, if the heating is intense enough, adjacent hydroxyl groups actually interact to split out a molecule of water, with the formation of an ether cross linkage. Undoubtedly, with gentle heating, additional hydrogen bonding does occur, for monomolecularly adsorbed water is driven off and the resulting force yields around the hydroxyl groups are reduced by interaction with each other in hydrogen bond formation. From infrared absorption spectra Ellis has shown the existence of hydrogen bonds in cellulose. It would be of interest to repeat the work and see what effect heating has on the intensity of the infrared absorption in the region of the perturbed OH groups. The formation of the previously postulated ether cross linkages at higher temperatures (200°C.) is, however, questionable. If such linkages do form, it would be expected that just as in the case with formaldehyde-treated wood, where cross linkages have been formed, the swelling in good wood swelling liquids should be reduced. Actually the swelling in 18% sodium hydroxide, pyridine, and morpholine is greater than is the swelling of the unheated wood in these liquids. Furthermore, if ether linkages do form on heating wood, it is necessary that the reacting hydroxyl groups be properly arranged in space. If they are far apart, such reaction could not occur.

Wood specimens were swollen in a saturated solution of potassium iodide. On drying, 65% of the water-swollen volume had been retained. These swollen specimens, together with unswollen controls, were heated at 220°C. for five hours. They were then thoroughly leached and dried. The hygroscopicity of both groups was found to be the same. Thus, even though the distance between hydroxyl groups which conceivably could interact was increased, heat treatment imparted to the wood the same reduced hygroscopicity as that imparted to the specimen heated in the nonswollen condition.

This experiment again suggests that the formation of ether cross linkages between swelling units is very unlikely when wood is heated. That the reaction which occurs is not one of oxidation is suggested by the fact that, whether wood is heated in air or in nitrogen, there results the same reduced hygroscopicity. Paper, if thoroughly swollen in glycerine and heated while submerged at 180, 200, and 220°C. for several hours, develops the same reduced hygroscopicity as paper heated dry and in the presence of air. The reactions occurring are not well understood. That they involve thermal degradation with the loss of volatile material is shown by the correlation between loss in weight and reduced swelling or hygroscopicity. Likewise, with loss in weight on heating, the strength properties deteriorate. Thus, if the swelling tendency of wood be reduced 50% by heating, the toughness is lowered by 60%. If the hygroscopicity of paper be reduced by only 20%, the fold resistance drops nearly 100%.

Thus, the use of heat treatment as a means of stabilizing dimensions or as a means of reducing the hygroscopicity of cellulosic materials has distinct limitations.

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Microscopical Analysis of Wool-Content Papers

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The percentage of wool in unsaturated roofing felts as determined by the microscopic method (using a weight factor of 3.10) was found to agree fairly well with the wool content found by the Kjeldahl method.

THE WOOL content of papers (roofing papers and linoleum stock) is, as a rule, determined by one of four methods: the alkali method, the acid method, the Kjeldahl method (*1*), or the microscopic method (*2–4*).

The alkali method is simple and rapid but should not be used where the wool content is less than 20%. The acid method is supposed to give results accurate to ±1.5%, but groundwood and other lignified fibers will alter the accuracy considerably. If only the percentage of wool is to be determined and other nitrogen compounds are not present, the Kjeldahl method for nitrogen is preferable since the wool content can be determined with an accuracy of ±1.00%.

However, since the wool content of both roofing and linoleum felts is, as a rule, a very small percentage of the whole, microscopic determination of the other types of fibers in these papers or felts is also important. Because of improved methods of fiber analysis and because a number of new fibers have been added to this type of paper stock (for example, Asplund fibers and synthetic fibers found in rags), it was of interest to determine the weight factor for wool fibers in such papers and also the accuracy of the microscopic analysis of the fiber furnish.

For this purpose six samples of unsaturated linoleum felts were obtained for which the manufacturer gave the following compositions:

I. 88.8% rag and 11.2% wool
II. 20.0% wood fibers, 71.0% rag, and 9.0% wool
III. 40.0% wood fibers, 53.3% rag, and 6.7% wool
IV. 60.0% wood fibers, 35.5% rag, and 4.5% wool
V. 80.0% wood fibers, 17.8% rag, and 2.2% wool
VI. 100.0% wood fibers

The nitrogen content of the samples was first determined by the Kjeldahl method (*6*), and the total percentage of wool present calculated by the following equation, assuming an average nitrogen content for wool fibers of 18.50%:

$$\text{(Percentage of nitrogen in paper} \times 100)/18.50 = \text{percentage of wool in paper}$$

This gave the following results: I, 10.26%; II, 7.56%; III, 5.57%; IV, 3.57%; V, 2.22%; VI, 0.54%.

For microscopic analysis, the samples were disintegrated without sodium hydroxide in the usual manner, thoroughly mixed in a malt shaker, and standard slides prepared according to TAPPI Standard T401 m-39.

Six slides of each sample were prepared and the fiber content was determined by the TAPPI standard for the 12 fields of the six slides, the total count of each kind of fibers (except the number of wool fibers) multiplied by the weight factor for each (*5*), and added together; this total divided by 100 minus the percentage of wool in the sample times 100 minus the weighted count of the nonwool fibers gives the weighted number of wool fibers. The weight factor of the wool fibers can be found by dividing the results by the actual count of wool fibers found in the sample. This is illustrated by the following calculations, using the data for sample I (see Table I):

Percentage of nitrogen 1.90 × 100/18.50 = 10.26% wool
Number of wool fibers = 76

Asplund fibers	× W.F. =	808
Coniferous chemical pulp	× W.F. =	126
Rag	× W.F. =	1623
89.74% of total	=	2557

(2557/89.74)100 = 2850
2850 − 2557 = 293; 293/76 = 3.85, the weight factor for the wool fibers in this particular sample.

By this method, the weight factor for the wool fibers of each sample was found to be: I. 3.85, II. 3.21, III. 3.94, IV. 2.41, V. 2.52, and VI. 2.66. The average factor is 3.10 ± 0.28.

Using 3.10 as the average weight factor for wool fibers, the percentage by weight of the different fibers in each sample was determined by multiplying the total of the count of the different fibers in all the fields of the six slides by the weight factor for each fiber.

These results, the comparison with the percentages of wool as found by the Kjeldahl method, and the furnish as stated by the manufacturer, are given in

Table I. Analytical Results for Wool-Content Papers

	Wood fibers: Coniferous Asplund fibers, %	Wood fibers: Coniferous chemical pulp, %	Rag, %	Wool, %
I. Manufacturer's statement	....	...	88.80	11.20
Nitrogen test	....	...	....	10.26
Microscopic test	29.00	5.00	58.00	8.00
Percentage error	1.32	1.32	2.92	0.59
II. Manufacturer's statement	.... 20.00	...	71.00	9.00
Nitrogen test	....	...	....	7.56
Microscopic test	47.00	4.00	40.00	9.00
Percentage error	3.87	0.48	2.92	0.72
III. Manufacturer's statement	.... 40.00	...	53.00	6.70
Nitrogen test	....	...	....	5.57
Microscopic test	58.00	3.00	34.00	5.00
Percentage error	3.00	0.38	2.25	1.30
IV. Manufacturer's statement	.... 60.00	...	35.50	4.50
Nitrogen test	....	...	....	3.57
Microscopic test	70.00	3.00	22.00	5.00
Percentage error	1.96	0.11	2.47	0.69
V. Manufacturer's statement	.... 80.00	...	17.80	2.20
Nitrogen test	....	....	...	2.22
Microscopic test	81.00	2.00	14.00	3.00
Percentage error	0.98	0.14	0.23	1.03
VI. Manufacturer's statement	.... 100.00	...	....	...
Nitrogen test	....	...	....	0.54
Microscopic test	95.00	1.00	3.00	1.00
Percentage error	0.67	0.38	0.46	0.37

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Table I. They show that the percentage of wool as determined by the microscopic method (using a weight factor of 3.10) in most instances agrees fairly well with the wool content found by the Kjeldahl method.

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Fast Cementing of Leather Belting Laps

SAMUEL L. ALLEN

This paper describes a method and the necessary equipment for accelerating the drying of waterproof nitrocellulose cement with infrared light in the lap of a leather belt when it is installed or shortened. It also summarizes the tests on which the method is based. Studies were carried out on a semiplant scale and showed that a minimum press board time of 10 minutes can be used and that the drying time should be approximately 30 minutes per ply of leather. The laboratory work involved studying the strength and speed of drying of various cements and such other factors as effect of viscosity, degree of nitration, per cent solids, various plasticizers, and formulation of solvents on the most promising cements. It also correlates the quality and strength of a lap with the press board application time and the drying time with and without the use of infrared light.

This paper describes a method for accelerating the drying of waterproof nitrocellulose cement in the lap of a leather belt when it is installed or shortened. It also summarizes the tests on which the method is based. Studies were carried out on a semiplant scale and showed that drying time can be very appreciably reduced by the use of infrared light. Since this method is very easily adapted to the particular needs of paper mills, it can effect a reduction of maintenance time or it can permit more belts to be cemented during a scheduled shut-down period.

To illustrate the use of this process, consider the installation of a new three-ply belt. After the machine is shut down, the old belt removed, and the new one placed on the pulleys, the important steps would be as follows: proper tension in the belt is applied through the use of belt clamps and rods; then the lap is fitted and scratched in the usual way. A nitrocellulose cement containing 18% solids with a viscosity of 700 cp. at 25°C. is recommended for both the sizing and sticking coats. One moderately heavy coat is applied evenly with a brush to all surfaces of the lap and dried thoroughly. The drying can be accelerated by using infrared light.

Figure 1 shows eight General Electric 250-watt, 110-volt reflector infrared industrial-type lamps mounted on 9-inch centers and placed so that there was 14 inches clear space between the face of the lamp and the leather. This spacing gives the correct amount of heat when the ambient temperature is between 65 and 70°F. The lamps can be conveniently mounted in short sections of knockout wire raceways and supported from the belt rods. The Chromalox Electric radiant heater, made by the Edwin L. Wiegand Company of Pittsburgh, RAD Series, may be used as an alternate source of heat. The 800-watt unit (RAD-308) placed at a distance of 18 inches from the belt may be considered to be the equivalent of the previous recommendation. The effective heating area would be 8 inches wide and 23 inches long for this particular unit. It is also available in 17- and 39-inch lengths.

If the leather is damp or the atmospheric humidity high, it is advantageous to apply heat to the lap for 5 to 15 minutes before applying the sizing coat. If this is done, the lap should be allowed to cool before the sizing is applied.

As soon as the sizing coat has completely dried, the lamps should be turned off. When cool, a light coat of cement brushed evenly on all surfaces, the lap closed, smoothed out and tacked to prevent slipping, and pressed between heavy boards with C clamps. A pad of sponge rubber on one side of the lap should be used to distribute pressure evenly over the lap.

After at least 10 minutes under pressure, the C clamps, boards, and pad are carefully removed, and the heat lamps moved back into position and turned on. The laboratory work shows that the following approximate drying times can be used: 30 minutes for a single ply lap is adequate, 60 minutes for a double belt lap, and 90 minutes for a 3-ply lap. The rods and heads are then removed and after trimming the lap, the belt is ready to run. This time compares

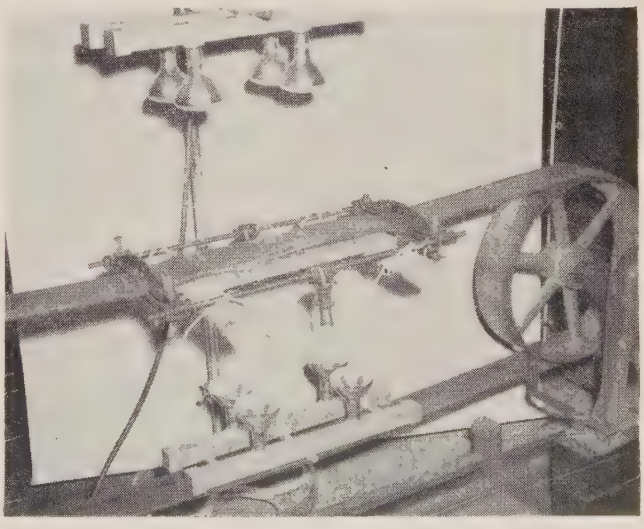

Fig. 1. Lap drying equipment

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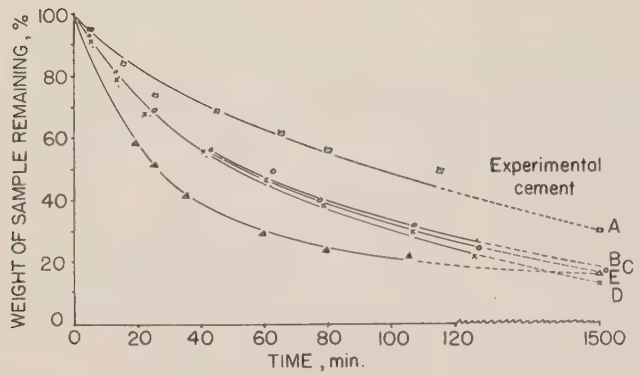

Fig. 2. Natural drying rates for experimental nitrocellulose cements

with 6 to 8 hours drying time recommended when infrared lamps are not used.

Good joints have been made by this method on both old and new belts, and under conditions of high temperature and humidity and even outdoors in a snow storm. Low temperatures, excess moisture, or oily leather call for slightly longer times than those indicated and very favorable drying conditions may permit shortening them slightly.

The laboratory work on which this method is based was conducted at the Wilmington, Delaware plant and included studies of the effect of viscosity, degree of nitration, per cent solids, various plasticizers, and formulation of solvents in the cement. It was found that good laps could be made with sizing cements ranging from 650 to 1200 cp. viscosity units at 25°C. and with sticking cements ranging from 100 to 750 cp. at 25°C. for both sizing and sticking since this cement gave the optimum penetration of leather and the desired ease of spreading with a brush.

CEMENT DRYING RATE STUDIES

In order to reduce the drying time, a study was made of the natural drying rates of several nitrocellulose type cements. It seemed obvious to use a cement with high solids content so that there would be less volatile material to evaporate. Higher degrees of nitration of cellulose permit higher per cent solids at the same viscosity but cements made this way, although initially strong, lost strength through flexure. Additions of various plasticizers to increase flexibility and reduce loss of strength through flexure also decreased initial strength. Figure 2 shows the natural drying rates of several of the cements studied when they were directly exposed to room temperature air. Of course, when the cement is between the plies of a lap at the same temperature, the drying rates are much slower.

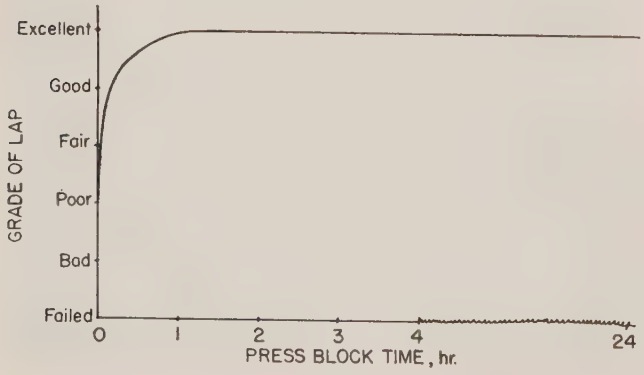

Fig. 3. Effect of press block time on grade of lap

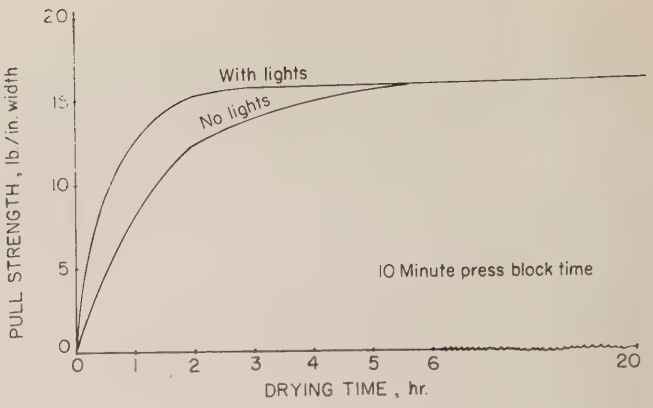

Fig. 4. Effect of drying time on lap strength (cement-B)

Solvents of various volatility were tried. The most volatile solvents cooled so rapidly that moisture was condensed on the cement from the air producing a porous and weak film. This can be detected by a milky appearance on the cement surface and is called "blushing." Less volatile solvents with drying accelerated by heat avoided blushing. Application of a heavy sizing coat and a lighter sticking coat permits escape of more solvent while the lap is open and solvent vapors do not have to escape through the leather. The amount of heat that can be applied after the lap is closed is limited by the ability of the vapor to escape through the leather. If the solvent is too volatile or too much heat used, the resulting high vapor pressure will produce a blister in the lap.

From these studies the cement that seemed most promising for fast cementing work with infrared light was selected and a series of experimental laps made with various pressing and drying times with the aid of the infrared light. The completed laps were then peeled open on a lap testing machine and the pull strength noted. Figure 3 shows the correlation between the press board time and the quality of lap. It was found that a satisfactory lap could be obtained in as little as 10 minutes press board time. Figure 4 shows the comparison of strength at various time intervals for laps worked with and without heat. As can be seen the recommended amount of infrared light gave considerable benefit in the time range of 1 to 2 hours.

Most of the work was done on 6-inch three-ply leather belts, both vegetable and combination tannages. Forty of the laps were made in a belt on pulleys and the laps tested by running the belts under tension. This method was later abandoned and the last 80 laps were tested by the peel test and by examination of the lap after peeling for uniformity of adhesion over the area of the lap. It was found that some experimental laps were strong enough to stand the running test but had flaws which might have caused trouble later.

The outstanding benefits of this method can be outlined in a few words: it insures the quick making of good laps when installing or shortening leather belting; it is good to use in damp and cool locations; and helps prevent the blushing of cemented surfaces when the humidity is high.

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Control of Slime in Groundwood Mills

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The causes and effects of slime development are discussed in particular reference to groundwood mill operation, with some comparisons made with other types of pulps and papers. Common sources of slime infection are reviewed, along with the usual methods for determining importance of the source of infection and the necessary corrective treatments. Particular reference is made to the use of break-point chlorination in the preparation of an ideal mill fresh water supply, and the resulting influence on quality of finished groundwood papers, such as those used for food packaging.

Some attention is paid to the physical arrangement or mechanical details of the groundwood system and the plea is made for correction of faulty construction in an effort to minimize product and quality losses. Recirculated white water systems are discussed, and the merits of the various bactericidal and fungicidal treatments are considered in keeping with the use requirements of the finished product.

Slime control in groundwood mill operation presents problems not greatly different from those of other types of pulp and paper production. It is, of course, true that chemical pulps or bleached rag stocks are more uniformly sterile and free of slime infection immediately after such thorough sterilization steps as cooking and bleaching. Catch samples of groundwood taken at the grinders will also show a majority of samples free of slime organisms. Slivers or shives, on the other hand, do not attain sufficiently high temperatures throughout their cross section, and therefore may constitute one of the first sources of slime infection. The breaking up or hydrating of these pieces and the release of the organisms carried by them deserve some consideration, if all points of entrance of slimes are to be corrected. It seems best to look first to the more active sources of slime troubles, and later to see what may be done to take care of the sporadic problems for which the pulp logs or the wood room or the log pond may be responsible.

Certainly the waters of the mill system must be considered as major pulp or papermaking materials. In the open system mill the fresh water may become a raw material of primary importance in the study of slime control methods. Almost without exception, the groundwood mill location and its selection of a fresh water supply will mean that the waters received in the mill will carry a heavy load of soil bacteria or cellulose-consuming organisms, and an abundant quantity of organic material upon which they feed. These quantities of food materials are, however, meager by comparison with the superabundance of the same foods available in considerable concentration in the groundwood mill system itself. Thus, it may be seen that clear spring waters or mountain streams, or even well waters that will show little or no sliming of themselves can still carry into the system enough organisms to thoroughly seed the mill, and to grow and multiply rapidly under these ideal environmental conditions to the point of causing troublesome slime accumulations, loss of production, and of quality of product.

These ideal environmental conditions, in addition to abundant food, include in almost all cases improved temperatures for rapid incubation of the organisms, and occasionally pH ranges that encourage both bacteria and fungi. Mechanically or physically the average mill is so designed or modified or otherwise arranged as to provide further ideal conditions for the seeding of the system and the encouragement of the accumulation of gelatinous or of stringy or rubbery slimes. Once such a system is seeded, slime troubles could persist in spite of the use of a truly sterile fresh water and possibly a truly sterile stock.

It has also been shown that slime infection or mill reinfection can be air-borne and may best be guarded against by presenting less favorable environmental conditions or by minimizing opportunity for such seeding or continuing infection by improving storage and ventilation facilities.

FRESH WATER TREATMENT

This discussion will not consider the physical clarification or the influence of clarification chemicals on the fresh water as a vehicle for seeding or continuing infection of the mill system. To varying degree, such clarification or chemical adjustment may decrease the bacterial load carried into the mill with the fresh water. Occasionally it is found that unfavorable water treatment methods actually aggravate sliming conditions. If the fresh water can be looked on as a vehicle, then chlorine sterilization treatment of the raw water can perform multiple service; by eliminating the slime-forming organisms at their source, improving and making more uniform the chemical, color, odor, and physical clarification, and employing the distribution of fresh water within the mill as a sterile means of diluting seeded slime infection, and also as a means of widespread introduction of residual sterilization effects in an effort to further reduce the numbers of slime-forming organisms being circulated or recirculated in the system. Some further attention will be given later on to the effects of reaction products and other control chemicals.

Contradictory as it may seem, not all sterilization treatments of chlorination applications are designed to produce truly sterile waters. There may be conditions under which it may be necessary to rely on bacteristatic rather than bactericidal effects. To some degree this choice may depend upon the final uses to which the groundwood pulp may be put, and most certainly will depend upon the nature of operations and system arrangement of the individual mill. Generally, however, there is more to be gained by designing

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for a complete sterilization, where it is possible to so design, or otherwise to approach as closely as possible to such thorough result as may be in keeping with the available facilities. Thus, it is assured that the waters are free of objectionable slime formers, certainly free of pathogenic organisms for the manufacturer of end-use food papers, and frequently, as an incidental, free of objectionable tastes, odors, and color that would detract from suitability of product for food papers or similar end-uses.

Chloramine and Break-Point Reactions

The chlorination of fresh water has been limited, until recently, by the controls placed upon it. It has been the practice to control such chlorination by applying sufficient chlorine to obtain a marginal or small chlorine residual. No emphasis has ever been placed on the type of chlorine residual; that is, free chlorine residual or chloramine residual, for no means was available for establishing which of these two was being obtained.

If ammonia was being applied along with chlorine, it was assumed, and rightfully so, that chloramine residuals were being obtained. Even when ammonia was not being applied, it is now known that many of these small residuals were chloramine for many waters contain at least enough ammonia or organic nitrogenous compounds to support a residual of small magnitude. To support a chloramine or combined residual of, say, 0.20 p.p.m. required no more than 0.04 p.p.m. of ammonia or organic nitrogen. Thus, as will be shown, those who practiced such chlorination were thwarted in their endeavors to eliminate all of the slime organisms from the water. Such practice never made obtainable a free available chlorine residual which, from the bacteriological angle, is of the utmost importance.

With the progress that has been made in the chlorination of fresh water and its control, there is available today to every groundwood mill the opportunity to deliver to all parts of the mill a water that for all practical purposes is sterile. This is obtainable by applying sufficient chlorine to obtain and to control, not any chlorine residual, but a free available chlorine residual. At first this may be possible at only a few points in the mill. Eventually it will be possible, as the system is cleared through continued chlorination practice, to do so throughout the entire fresh water system of the mill.

Many New England and Eastern Canadian surface waters are so deficient in ammonia content that merely increasing the application of chlorine to give a higher chlorine residual of 0.50 to 1.00 p.p.m. will result in a free chlorine residual. The reason for this is that the maximum chloramine residual obtainable, with the small quantities of ammonia in the water, may be only 0.20 to 0.40 p.p.m. Any further attempt to increase the chlorine residual above this value merely results in the destruction of this chloramine residual, and then the 0.50 to 1.00 p.p.m. residual is composed chiefly of free chlorine. In a few instances the water has been so devoid of ammonia or organic nitrogenous materials that even the smallest chlorine residual obtainable has been free chlorine. Other waters in other sections of the Country when chlorinated go to the other extreme. Some contain relatively large amounts of ammonia and increasing applications of chlorine at first merely result in increasing the chloramine residual. However, if the application of chloramine is increased still further the chloramine residual will decrease through destruction, and if enough chlorine is applied it will be supplanted by a free chlorine residual. Any chlorination which is controlled to a free chlorine residual, whether the water is devoid of ammonia or not, is known as free residual chlorination. If the chlorination goes through the chloramine cycle mentioned above, it is free residual chlorination by means of the Break-Point Process. In such a process care must be exercised in its control to distinguish quantitatively between free chlorine residuals and chloramine residuals.

It is now known that if a water containing ammonia is chlorinated, and its pH is around 7.0 or above, the full amount of the mono-chloramine (NH_2Cl) will be formed. If the ammonia is in excess by about one-fifth of the chloramine residual reading, the chloramine residual will be stable unless consumed by material easily oxidized such as hydrogen sulphide. If the chlorine is in excess, the mono-chloramine will start to convert to dichloramine ($NHCl_2$). The mono-chloramine and dichloramine will react with each other to release nitrogen and thus destroy the chloramines. The reaction is seldom as clear cut as this. An excess of chlorine accelerates this reaction and at the same time with great rapidity converts mono-chloramine to dichloramine. This latter reaction is usually the fastest so that by the time the mono-chloramine and dichloramine have reacted with each other, there is an excess of dichloramine left. An excess of the free chlorine applied likewise accelerates the decomposition of the dichloramine. At the higher pH values only a very small fraction of the dichloramine is converted into nitrogen trichloride by the excess free chlorine residual. Surprisingly enough most of the free chlorine does not enter into reaction with the dichloramine, but merely acts as a catalyst in allowing the dichloramine formed to react with the water and through this hydrolysis break down into nitrous oxide gas, which if in a sufficient amount, will impart a sweet taste and odor to the water.

At pH values below 7.0 the reaction is one in which dichloramine is slowly formed. The dichloramine is stable just so long as the ammonia is in excess by about one-eighth or more of the chloramine residual. If an attempt is made to form the full amount of dichloramine residual; that is, a ratio of 1 part ammonia to 10 parts of chlorine, the dichloramine being gradually but slowly formed is completely decomposed in the presence of excess chlorine to nitrous oxide as described above.

The importance of these reactions and their control is that the chlorine at normal pH levels reacts with the ammonia almost immediately to form mono- and dichloramines, and that any free chlorine residual in the water a minute or so after chlorination remains at that level, except for the amount that is slowly consumed with time, by the organic material in the water. Immediately after chlorination the total chlorine residual will be composed of free chlorine and chloramine. If there were no further chlorine demand

of the water with time the free chlorine fraction of the residual would be practically constant; whereas the chloramine fraction of the residual, the dichloramine, would disappear through hydrolysis with the water. Sometimes organic chloramines are formed and these are not completely destroyed. In practice any further reduction of the free chlorine residual, excepting sunlight which decomposes it, gives an index of the organic load of the water and of the distribution piping system which it enters. The latter is initially the source usually of greatest demand. Thus, the extent or the rate at which a free chlorine residual can be carried through a mill fresh water system is usually the index of the degree that slime is present in this system.

The importance of obtaining and then maintaining this free chlorine residual throughout a mill fresh water system is of the utmost importance. The residual itself should be well understood. The free chlorine residual is nothing more than a residual or excess of the chlorine in whatever form it has been applied and which has adjusted itself according to the pH of the water.

If the pH of the water is 6.5 or less the free chlorine residual is composed entirely of hypochlorous acid (HOCl) and the same as if chlorine water (mostly HOCl and some free molecular chlorine) had been applied to the water or the same as if chlorine gas, Cl_2, had been applied to the water and reacted with it. If the pH of the water is increased above 6.5, the free chlorine residual becomes composed of lesser amounts of HOCl and greater amounts of hypochlorite ion (—OCl). At a pH of about 7.5 the residual is nearly an equal mixture of each. At a pH of 9.5 to 10.0 and greater, the residual is composed entirely of hypochlorite ion the same as if a hypochlorite solution of calcium or sodium hypochlorite had been applied to the water. Thus, whether chlorine is applied as a gas, as a chlorine water, or as a hypochlorite, a residual of what has been added is in the form of hypochlorous acid, hypochlorite ion, or a mixture of the two in the water, depending upon the pH of the water.

The active killing agent for the slime organisms is the hypochlorous acid and in this respect the relation between the hypochlorous acid and the hypochlorite ion and the pH of the water is of importance. The amount of hypochlorous acid and hypochlorite ion percentage-wise always remains the same in the free chlorine residual just so long as the pH remains constant, although the chlorine residual may be diminishing and the hypochlorous acid rather than the hypochlorite ion may be consumed. The hypochlorous acid and the hypochlorite ion are always in equilibrium and in the same equilibrium at a given pH. Thus, at a pH of 7.5, a 1.00 p.p.m. free chlorine residual would be composed of 0.50 p.p.m. chlorine as hypochlorous acid and 0.50 p.p.m. chlorine as hypochlorite ion. If the water or distribution system consumes 0.40 p.p.m. of hypochlorous acid with a resulting free chlorine residual of 0.60 p.p.m. chlorine this free chlorine residual would not be composed of 0.10 p.p.m. chlorine as hypochlorous acid and 0.50 p.p.m. chlorine as hypochlorite ion, but rather 0.30 p.p.m. chlorine as hypochlorous acid and 0.30 p.p.m. chlorine as hypochlorite ion. Although 0.40 p.p.m. chlorine as hypochlorous acid is consumed out of 0.50 p.p.m. originally present there still remains 0.30 p.p.m. chlorine out of 0.50 p.p.m. originally available for killing organisms. Thus, the hypochlorite ion even has a value in that it acts as a reservoir for the active sterilizing agent, hypochlorous acid.

Free chlorine residuals as hypochlorous acid kill organisms very fast; at normal pH values only 2.5 to 3.0 minutes are needed. The killing rate is materially delayed when the pH is increased to 9.5 or 10.0, which is another way of saying that the free chlorine residual contains little or no hypochlorous acid. At such pH values the killing agent is at a minimum. Chloramines also have a decreased effectiveness as killing agents with increasing pH values. Although chloramines and free chlorine are slow killing agents at higher pH values, it is known that chloramines at pH values of 9.0 to 9.5 do kill faster than free chlorine residuals. This is the only pH level, however, at which chloramines are better bactericides than free chlorine, but the effectiveness of each type of residual at this pH is so low as to be generally discouraged. At the pH levels normally obtained in chlorinating water the chloramines are decidedly less efficient as bactericidal agents. Butterfield and Wattee in the Public Health Reports, Volume 61, No. 6, page 157 (February 8, 1940) state that to obtain a 100% kill with the same contact times required, for several organisms, about 25 times as much chloramine as free chlorine. Furthermore, to obtain the same kill with the same amounts of chlorine and chloramine under the same conditions requires approximately 100 times the contact period for the chloramine as against the free chlorine.

Chlorine Application

The application of chlorine for free residual chlorination to fresh water for a groundwood mill should be to the water as it enters the mill. If there is a treatment plant in use, it should at all times be ahead of any treatment that is employed. The unchlorinated filtered waters of many mills contain more slime infection than the incoming raw water. This is evidenced by the slime accumulations on the sand beds and the walls and troughs of the filters. Settling basins give similar evidence. Thus, it is basic to chlorinate to free chlorine residuals ahead of all units of the treatment plant, and to maintain the free chlorine residuals throughout the entire treatment plant and to the water being delivered to the water distribution system of the mill. Such chlorination has the added advantage of removing iron, manganese, aiding coagulation and affording the contact time required for removing color and tastes and odors.

If a mill distribution system is suspected of containing considerable slime, the free chlorine residual entering that system should be small at first, say 0.2 to 0.5 p.p.m., and gradually increased. If the mill has a shutdown period, the pipe line can be heavily chlorinated at that time. Observations as to slime sloughing off will regulate the speed with which this residual can be increased. Sampling points within the distribution system will indicate the rate of progress. The important thing to remember is that eventually effective slime control will only have been established when a free chlorine residual is found throughout the distri-

bution system where it comes to the point of contact with pulp, or stock and white water. In practice in some parts of the system the free chlorine residual may reach the magnitude of 5 to 10 p.p.m. in order to get the barest 0.2 to 0.5 p.p.m. in some other part of the system. As the system, however, gets thoroughly cleaned and the slime in the pipes eliminated, the chlorine application which was gradually increased to a peak can then be tapered off as the residual to various parts of the system become more uniform.

The presence of free chlorine residual is not in itself going to account for corrosion in spite of contrary expectation. Where corrosion has occurred, it has been due to an initial low pH of the water, the natural aggressiveness of the water itself or a lowering of the pH of unbuffered waters due to chlorination. It is to be remembered that for every part per million of chlorine applied approximately 1.2 p.p.m. of the alkalinity expressed as calcium carbonate is neutralized and lost. In many New England surface waters and Eastern Canadian waters where alkalinity is quite low, chlorination of any magnitude could result in a loss of a major portion of the alkalinity and thereby drive the pH down to an unbalanced level. In such cases it is advisable to keep the pH of the chlorinated water up to 6.5, certainly up to a pH of 6.0 by applying to the water sufficient lime, soda ash, or caustic soda. The control of free chlorine residuals is not a difficult procedure. Such residual gives an immediate color with ortho-tolidine as opposed to a slowly developing color with chloramines and ortho-tolidine. The addition of arsenite immediately after the color is formed with ortho-tolidine will destroy the chloramines and thereby prevent their reacting with ortho-tolidine. This then gives the operator ample time to read the color value of the free chlorine residual. Such a residual can also be determined amperometrically by means of an amperometric titrator. In such an instrument free chlorine residuals cause the passage of a current through a cell and this current is recorded on a galvanometer. Chloramines cause no current to be passed. Since only free chlorine residuals are being controlled it is only necessary to add arsenite solution in terms of residual chlorine until the galvanometer no longer deflects indicating that the free chlorine is completely neutralized.

PHYSICAL DETAILS OF SYSTEM

It has been remarked that the fully open system is rather rare to find. Such a system could certainly be maintained essentially free of slime difficulties by a break-point chlorination of the fresh water providing the focal points of reinfection within the mill were completely searched out, periodically cleaned and sterilized, or entirely eliminated by mechanical correction of the fault. Dead end pipe lines or fittings, or oversize piping proper may be some of the most readily corrected points of potential trouble. Old corroded or roughened pipe might be replaced or relined, and all joints in which slimes may build up can be filled or streamlined by suitable means. Suction and seal boxes, flumes, and tanks and chests should be checked carefully, dead corners and roughened surfaces filled and smoothed or lined in an economically satisfactory manner. Dual tanks and chests should be studied for improper circulation and for opportunity for fibrous materials and slimes to hang up and accumulate. Oversize tanks and chests should require equally critical study. Factors promoting foaming and splatter need to be studied and corrected. The many points that require mechanical improvement are almost too numerous to discuss, and as an increasing recirculation and reuse of white water takes place, these critical points multiply in number and in importance.

Before considering the progressive steps of white water reuse, it may be best to discuss briefly some specialized clean-up procedures for the open system mill, and subsequently to note in what way these procedures become even more important in closed system operation. If slimes have been kept well under control, a simple emptying and flushing or hosing of lines and tanks will suffice to remove fibrous accumulations.

If for some reason mechanical faults are continued, they will encourage tougher slime accumulations in sections having low velocities or poor circulation, and in which the fresh water break-point chlorination does not have sufficient opportunity to provide adequate control of the seeded slime forming organisms. In such cases, depending upon the accessibility for scraping or scrubbing, it may be necessary to utilize chemical methods to assure a thorough clean-up. Provision can be made to automatically increase the chlorine residual in the fresh water lines during the clean-up in order that the clean-up hoses will carry on effective sterilizating solution to the points of seeded infection. The beneficial effects of such sterilization are marked, particularly from standpoint of off-odors developing during relatively prolonged shutdown, and are generally recognized as effective in retaining the development of slimes or of high bacterial counts as the mill resumes production.

Where the trouble spots are not accessible to the sterilizing hoses, and it may not be feasible to flood and flush the section with fresh water carrying the higher chlorine residual, the mill may find it necessary to utilize caustic or prepared alkaline cleaning compounds to react upon and free up the tougher accumulations and thus, either alone or in combination with flushing with the higher chlorine residuals or the use of the phenols or mercurials, to provide a sufficiently thorough sterilization of the water-contact surfaces to retard development of odors, tastes, colors, high bacterial counts, and troublesome slime growths. There are cases in which some benefit appears to result from a flushing or swabbing of accessible surfaces with the alkaline solutions, or with solutions of the phenols or mercurials. Care must of necessity be observed not to overdo the treatment nor to leave residues or pockets of the toxic materials that can be picked up in excessive amounts by the product upon resumption of production. To avoid the possibility of serious overdoses, there is considerable merit to the controlled proportional application of these toxic agents to the waters used for spraying or flushing during clean-up, as well as during normal production, where applicable, and where acceptable in keeping with end-uses such as food container papers.

WHITE WATER

As white water is progressively utilized to replace former fresh water uses, two consequent reactions take place. The fresh water is no longer the same effective vehicle to carry the sterile dilution of bacterial population into the stock system, and to transmit the killing effect of the free available chlorine residuals to combat seeded slime infection. At the same time the white water has opportunity to return a reinfection to the system and therefore to increase the bacterial population at a greater rate than the indirect fresh water chlorination can reduce the slime infection. One of the first points of white water reuse will be the grinder pits and the bull ditch. Even though the freshly groundwood may be essentially sterile at this point, it is perhaps at its most ideal temperature and pH for rapid incubation of the slime organisms inoculated by the returned white water. It is not surprising, therefore, that slime accumulations will increase rapidly at the rifflers, knotters, and fine screens. As white water may subsequently be used for showers on the bull screens, knotters, fine screens, and for dilution jets, the reinfection tends to pyramid, and it becomes obvious that secondary protection must be provided if the heavy growths and carry-overs in the deckers, thickeners, or wet machines are to be controlled.

The common or most logical source of white water for these purposes would be the discharge from deckers or thickeners. All too often the progressive uses of this white water will mean that separate gravity flows or pump take-offs will be drawn from a common tank or a series of white water tanks. Such a mechanical arrangement makes difficult a uniform effective sterilization treatment of the returned white waters. In a case like this it may be found necessary to apply the corrective treatment to the white water as it enters the tank or tanks providing the overflow to waste from the tanks is at a minimum, even when pulp is being lapped. When the groundwood is being sluiced to the paper mill, there will be either fortunately a fresh water make-up to the white water system, or less fortunately a return of surplus white water from the paper machines. When this occurs, the opportunity for heavy slime infection multiplies manyfold.

The first necessary step is to endeavor to modify the in-put or the out-flow to allow a single common point of chemical treatment, and to make sure that no dead areas, no excess volumes, and no bypasses are permitted. If all of these changes are not physically or economically possible, the treatment system and application methods must be designed to suit the flume or tank or piping layout that must continue.

Selection of proper sterilization treatment will again depend to some degree upon the end-uses of the groundwood pulp or groundwood papers. Until recently only chlorine or chloramines have been acceptable for food papers. There is now some evidence that the Food and Drug Authorities will allow the use of measurably small amounts of mercurials or phenols with the proviso that the applications will not constitute a contamination of the finished product. Mention has been made, for instance, of a top level of 0.1 p.p.m. of mercury. It is natural to suppose that a production suspected of exceeding such an amount would be subjected to critical survey, particularly directed toward the methods and controls used in the application of the corrective chemicals to the stock in process. It would be most convenient to apply these chemicals, either separately or in combination, to the single common point in the recirculated white water system as described heretofore, and in this way to take advantage of the widespread distribution throughout the groundwood system afforded by the reused white water as a vehicle much as the open system fresh water had served as a multiple-purpose vehicle.

The next logical step is to recognize, by test, or by progressive experience, the specific selective action of the various slime control chemicals in combating the infecting organisms that may be seeded in the system, or may enter with the stock or may be air borne. As experience is extended, it will be determined to what degree chloramines will perform to greater advantage than chlorine alone in the presence of the heavy organic load characteristic of the white water system. If under the conditions of treatment with chlorine or chloramines it develops that additional benefits are needed that can be provided by dispersing agents or by phenols or the mercurials, each of these chemicals must be tested separately and in balanced combination, under positive control, in order that each may be evaluated for its specific selective bactericidal or bacteristatic properties. Only in this way may the optimum levels of controlled treatments be established with the ultimate purpose being to arrive at a proper economic balance of cost of treatment against operating returns. Experience has generally been that the finally adopted schedule of treatments will utilize a minimum of the more expensive materials, and an increasing usage of the more economical combinations of chlorine, chloramines, phenols, mercurials, and others, aided by the dispersing agents, and by specialized clean-up chemicals and methods, generally in that order of preferential selection.

CHANGES IN MILL LAYOUT

Just as the white water reuses are known to develop by a system of evolution, the over-all mill characteristics will change with time or with growth. Not only must the mill keep in pace with the changing seasons, and their influence on the balance of effective slime control measures, but the mill must also keep an active eye on the effect of mill changes, and equipment additions or improvements, on the efficiency of the slime control treatments. For example, installation of additional grinders or other increase in grinding capacity without proportional adjustment in chemical applications may defeat a well-established slime control. Additional deckers or thickeners may be installed without recognition of the need to modify methods of returning white water to the common point of treatment. Additional white water may be returned from the paper machines or the system may be interlocked with the chemical pulp mill. The hydrosulphites or peroxides may be introduced as a new method of brightening or bleaching the groundwood. More economical showers may influence the degree of distribution and use of treated fresh water and white water. All of these factors, and again too many more to permit discussion

here, will all have their effect on the success of a well-established slime control.

Failure to recognize these important factors has in the past frequently given rise to a mistaken view of an apparent immunity building up on the part of the infecting slime organisms. Each of the known slime formers has a well-established resistance to any one or to all of the commonly used slime control chemicals. If the levels of treatment are not maintained at or above their established rates of application, or if changes in mill operation or layout are not accompanied by corresponding changes in chemical application, it is simple to see how the surviving organisms may be encouraged to grow at an accelerated rate. It is well recognized that the average mill stock or white water system represents a mixed suspension of organisms, naturally aggressive toward one another and tending to keep one another in a form of numerical balance under the conditions existing in the particular environment in which they find themselves. If seasonal, physical, mechanical, or chemical changes occur there is a possibility that the control of one or more of the infecting types of organisms may be lost, and these types will develop at excessive rates. If the necessary changes in slime control applications are not made to suit these new conditions, it may appear to the inexperienced that the original organisms have developed a so-called immunity to the treatments that have in the past been successful, and the unfortunate sequence is that the normally effective treatments are discarded, and unstudied applications of completely foreign treatments will be attempted. These will logically show a temporary shift in the characteristics of the slimes remaining. Ultimately the result is that alternating treatments are set up that attempt to keep the slime characteristics shifting from week to week rather than to recognize and make effective use of the selective actions that are so well demonstrated by the very fact that the different slime characteristics can be in this way controlled or shifted from week to week. At this point a careful evaluation of the relative effects of the alternating treatments will, by experience, yield an efficient, economical, combination treatment that will take full advantage of the selective bactericidal and fungicidal controls of the various chemical applications that have been proved powerful enough to keep the several types of slime forming organisms under a practical and economic balance. In this way continuous controlled applications of the various slime control chemicals will prove to be the most efficient means of assuring a slime-free low bacterial count and low cost means of producing a high-quality groundwood pulp, suitable for any ultimate end-use such as food container papers, newsprint, or other common application.

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The Manufacture of Groundwood for Newsprint

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Mechanical pulping, screening and refining equipment discussed generally. Uniformity of product stressed for efficient high-speed newsprint machine operation. Ideals in wood and wood condition for uniform pulp quality stated. The importance of and the selection of pulpstones to suit the wood condition and the paper machine requirements in pulp quality for any particular mill are also discussed.

Even though separate papers have been given on grinders, screens, systems etc., it is necessary to discuss generally the various types of equipment used in the manufacture of groundwood for newsprint. The author has also taken some liberty with the subject and has included his thoughts on what should be contained in an ideal mechanical pulp mill.

In use today and producing suitable quality mechanical pulp for newsprint at comparative power, maintenance, and labor costs, are three types of magazine grinders, namely, the ring or horn angle continuous grinder, the caterpillar continuous or chain type, and the hydraulic pressure foot type with either high or low magazine. The side pocket grinder with hydraulic pressure foot while it produces pulp at comparable quality for a given horsepower per ton with the continuous grinders does so at an increased labor cost.

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The ideal grinder, of course, is the one of true continuous principle; however, to date to the writer's knowledge no advantages in tonnage capacity and power savings, for comparable pulp quality, can be claimed for the continuous principle over the hydraulic magazine types of grinders. It is his opinion that the continuous type will show improvements in uniformity of product in installations where the full advantage of stone surface speed is taken to account, and available power is stepped up proportionately.

In large operations today practically all have gone to the use of the Pascal screen for the initial screening step after the grinders. Some new installations have been made with a small high-frequency vibrating screen. Accepted tonnage per unit on the Pascal type is around 125 tons per day with $^{3}/_{16}$-inch perforations. Second stage or fine screening in most of the large installations in Canada is done with rotary screens using perforated plates varying from 45 to 65 thousandths. Fine screening itself is done usually in two stages using the same plate perforation size and varying the entering consistency of the second stage to control dirt. The consistency of the first stage of the fine screen operation is usually held as near constant as possible and most mills control this at the bull screens. Entering consistency to the fine screens varies from mill to mill depending mostly on the per-

foration size used and the grade of newsprint pulp made. The range covered is from 0.45 to 0.70 consistency although some of the new screen installations operate at an entering consistency close to 1%.

The capacity of these screens varies with the perforation size, the entering consistency, and the pulp grade, and accepted tonnages per unit of screens of the same make will vary from 45 to 85 tons per day. Even higher accepted tonnages with a new type rotary screen that has come into prominence the last few years is being experienced.

Thickening of the pulp for storage is usually done with 8 by 16 foot filters having vacuum scroll dischargers, jet lifters and slides, and even couch rolls with doctors. Capacity of these units vary from 45 to 70 tons per day on the normal range of newsprint groundwood freeness and system temperatures from mill to mill. Some of these filters are equipped with separating devices for lean and cloudy white water which is an asset when white water is required on the paper machine showers to help maintain system temperatures.

Although improvements in the runner of an older type of screen and the use of a new type have stepped up screening consistency with a consequent increase in filter capacity, screens which will operate at at least 3% consistency should be developed. This operating consistency would automatically eliminate the need of thickeners, the huge volumes of recirculated water, and the costly buildings required to house this equipment.

With the refiners at present on the market the reducing of former waste into an acceptable portion of the newsprint furnish is readily accomplished. It is now possible to put everything including bull screen rejects back into the sheet without detriment to it, and to have accepted yields in the groundwood mill of slightly better than 95%. With wood at its present high cost it is doubted if there is another piece of equipment capable of such high returns on investment in the pulp mill.

The proper selection of pulpstones for the wood condition and the paper machine requirements of any mill reduce the burring of a stone to a simple mechanical operation requiring little skill.

Knowing wood not only by species but by density, moisture content, and age since cutting and whether it will come to the mill separated as to any of these items or in a known mixture, allows one to select the correct pulpstone to meet the requirements of the paper machines.

Having the correct grit range and stone structure for the operation burring develops into a simple mechanical operation whereby the burr is set into the stone to a predetermined depth and moved across the face at a predetermined rate exposing new surface. Oversharpening and the suppression of stone surfaces by rolling with smooth steel shells or abrasive rolls practically disappear. In other words, with proper knowledge of the raw material, wood, and the pulp requirements of the paper machines, it is possible to select pulpstones which naturally make pulp in the freeness and quality range desired when they are sharpened to a predetermined burr depth and at the correct traverse speed using the mechanical means now available.

Considering the respective merits of the three main species of wood used in the East it should be pointed out that all the inherent qualities of spruce, balsam, and jack pine can only be brought out by grinding separately and with the correct pulpstone. However, whatever the species used it should not be below 40% in moisture content if its full pulp-making qualities are desired. Age of wood since cutting is also a factor and wood should be used from piles in rotation. It is the writer's experience that steadier operating conditions are obtained from wood which has been random piled and then reclaimed to the mill than with it coming directly from the bush operation no doubt due to the mixture evening cross sectioning effect of the reclaiming operation.

To discuss an actual operation the Baie Comeau mill of the Quebec North Shore Paper Company, is considered because the pulp operation is supplying two 244-inch trim paper machines running at an average speed of 1630 f.p.m. including start-ups making an average of 483 tons per day at an over-all mill efficiency of 93.5%.

The wood is made up of 75% black spruce, 20% balsam, and 5% jack pine. Wood to the mill is never over 1 year old since cutting and it averages 43% moisture with a density of 0.425. Species are not separated due to the handling cost involved except to make sure that all the jack pine goes to the groundwood mill. Any wood that has become dry through being tiered is also separated and diverted to the sulphite operation.

The grinder room has 16 hydraulic magazine grinders with 3600-hp. motors, two stones per motor. The peripheral speed averages 3650 f.p.m.

Artificial stones are used with a pit consistency between 3 and 4% and a pit temperature of 185°F. For control purposes in the grinder-room hourly production readings are taken from the counters, which are not very accurate, and the stock is examined by blue glass whenever required. The pit temperature is seldom changed as the sharpening method seldom makes a stone overcut. The load on individual lines are varied for freeness control from 3100 to 3700 h.p. whenever in the operator's opinion the falling or rising freeness is caused by the wood condition and not the pulpstones. A mixed stock freeness of 65 Canadian Standard ranging from 62 to 67 is held except that when the wood is drier than normal it goes to a lower range, when top motor loads have been reached, to maintain the physical qualities of the pulp. No advantages have been found in grinding at a pit consistency below 3 to 4% either in power or pulp quality.

In conclusion it would seem that judicious selection of stones, proper segregation of wood for moisture and for species, if possible, would allow one to make good quality newsprint groundwood with the present grinding and screening equipment available. To advance, however, beyond the present stalemate requires considerably more fundamental study of the grinding process.

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The Solubility of Sulphur Dioxide in Magnesium Bisulphite Solutions

FRANK H. CONRAD and DONAT B. BRICE

The Duhring relation was applied to a 3-phase, 3-component system for the determination of the solubility of the combined sulphur dioxide. The experimental data at 15 and 25°C. were extrapolated for 5, 35, 50, and 60°C. and single solubility determinations at 35°C. add greatly to the reliability of the work. Pressure composition curves are presented in terms of combined and total SO_2 for temperatures ranging from 5 to 60°C. Comparison with data of other workers for the unsaturated region where but liquid and gas phases are present, indicates that *p-t-z* diagrams [$p - p_s = k(t - 1.95z)$], where p = SO_2 pressure above solution, p_s = SO_2, pressure above a saturated solution t = total SO_2 per 100 grams H_2O, z = grams combined SO_2 as in $MgSO_3$ per 100 grams H_2O, will describe the system MgO–SO_2–H_2O for the range of 5 to 60°C. and total pressure to 1 atmosphere.

Since certain of the sulphite pulp mills are converting to the use of magnesium base pulping, it becomes necessary for proper design and control to know the solubility of sulphur dioxide in various concentrations of base at different pressures and temperatures. Smith and Parkhurst (*8*) investigated the solubility of sulphur dioxide in suspensions of magnesium hydroxide covering a range of 0 to 1 *N* for alkali concentrations and a pressure range from 46.6 to 595.3 mm. of Hg partial pressure of sulphur dioxide. All of their data were below the saturation values for magnesium bisulphite. Equilibrium data for the system magnesium oxide–sulphur dioxide–water have been determined by Conrad and Brice (*5*) at 15 and 25°C. at pressures below atmospheric. Also the equilibrium values have been ascertained at 35°C. and atmospheric pressure.

Table I gives the equilibrium data as read from smooth curves drawn through the experimental points (*5*). Magnesium bisulphite is much more soluble than calcium bisulphite (*3, 4*) at the same partial pressure of sulphur dioxide. Also the ratio of the total to combined SO_2 was in all cases investigated, less than two, this ratio differs from the calcium system. The ratio of total to combined SO_2 for all saturated solutions was approximately constant, varying from 1.84 to 1.98. The ratio increased slightly with a large increase in partial pressure of sulphur dioxide.

Since most commercial cooking liquors will probably not be saturated but will contain some dissolved gas in addition to that required to form the bisulphite, the equilibrium data were combined with the recalculated data of Smith and Parkhurst (*8*) in the form of *p-t-z* diagrams for the range of commercial cooking liquors. These authors have stated that varying proportions of calcium or magnesium have no effect upon the equilibrium concentration of sulphur dioxide present as sulphurous acid. Figures 1 and 2 show the solubility of sulphur dioxide in aqueous solutions of magnesium bisulphite at 15 and 25°C.

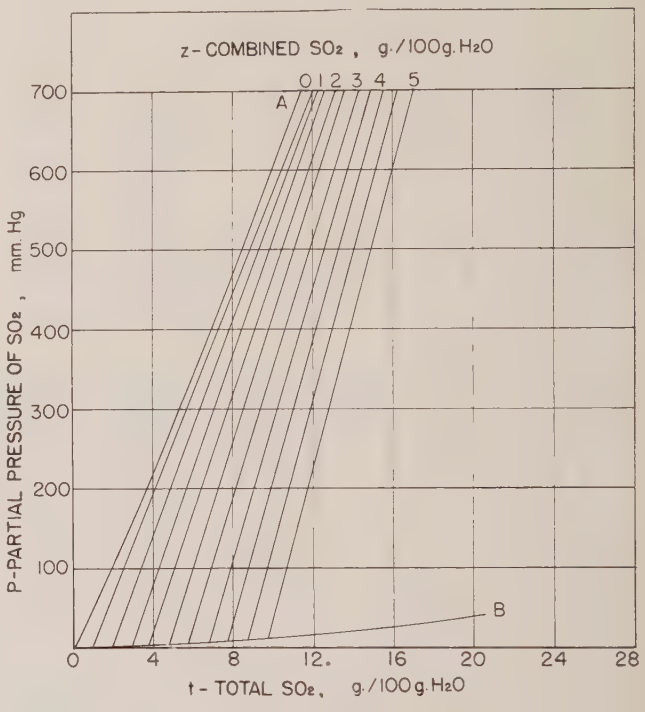

Fig. 1. p-t-z Diagram for 15°C.

The lines OA on all *p-t-z* diagrams are the solubility of sulphur dioxide in water (*7*). The curves OB represent the saturation lines and have been constructed from the equilibrium data of reference (*5*) for Figs. 1 and 2. The curves OB on the other *p-t-z* diagrams are predicted saturation values based on an extrapolation using Duhring's Rule (*6*). The straight lines of positive slope represent constant values of combined sulphur dioxide or equivalent magnesium sulphite. These lines have been constructed using the experimental work of Smith and Parkhurst (*8*) to obtain values of total SO_2 at 500 mm. partial pressure of sulphur dioxide. Their data were graphically interpolated at constant pressure to obtain the total sulphur dioxide for chosen values of combined sulphur dioxide. Since their data were presented in grams of SO_2 per 100 ml. of water, it was necessary to convert this to grams of SO_2 per 100 grams of water. Points on the saturation curves OB were obtained for the

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same chosen values of combined sulphur dioxide by plotting $t = 1.95z$. The constant 1.95 is approximately the average ratio of t/z as shown in Table I. The lines of positive slope were then drawn by connecting the values of t at 500 mm. Hg with the values of $1.95z$ on the saturation curve.

combined SO_2 are straight and pass through the abscissa at a value of $t = 2z$ ($p = 0$) it is theoretically incorrect to combine their values with the values from the present paper to obtain the slope of the constant combined lines. Actually, however, little error is introduced as their work was only used to locate the

Table I. Composition of Liquid Phase in Equilibrium with a Solid Phase for the System Magnesium Oxide–Sulphur Dioxide–Water

Smoothed Data of Conrad and Brice (*5*)

Total pressure, mm. Hg	*Concentration of sulphur dioxide at 15°C., grams per 100 grams H_2O*				*Concentration of sulphur dioxide at 25°C., grams per 100 grams H_2O*			
	Total t	*Combined* z	*Free* t − z	*Ratio* t/z	*Total* t	*Combined* z	*Free* t − z	*Ratio* t/z
50	20.0	10.5	9.5	1.90	11.0	5.7	5.3	1.93
100	29.4	15.4	14.0	1.91	23.0	12.5	10.5	1.84
150	34.5	18.0	16.5	1.92	30.2	16.0	14.2	1.89
200	38.5	20.0	18.5	1.92	34.9	18.4	16.5	1.90
250	41.7	21.7	20.0	1.92	38.2	20.2	18.0	1.89
300	44.2	23.0	21.2	1.92	40.8	21.5	19.3	1.90
350	46.2	24.0	22.2	1.93	43.4	22.4	21.0	1.94
400	47.9	24.8	23.1	1.93	45.6	23.5	22.1	1.94
450	49.5	25.4	24.1	1.95	47.5	24.2	23.3	1.96
500	50.9	26.1	24.8	1.95	48.7	24.8	23.9	1.96
550	51.9	26.5	25.4	1.96	49.8	25.3	24.5	1.97
600	52.7	27.0	25.7	1.95	50.7	25.7	25.0	1.97
650	53.4	27.4	26.0	1.95	51.5	26.0	25.5	1.98
700	53.8	27.6	26.2	1.95	51.9	26.3	25.6	1.97
728.7[a]	50.1	25.7	24.4	1.95				

[a] Experiment at 35°C.

The value of the ratio t/z is perhaps one of the best ways of pointing out the difference between the magnesium and calcium systems. The values of t/z for the calcium system (*3*) range from 2.07 to 3.24 for the temperatures of 15 and 25°C. over the same pressure range.

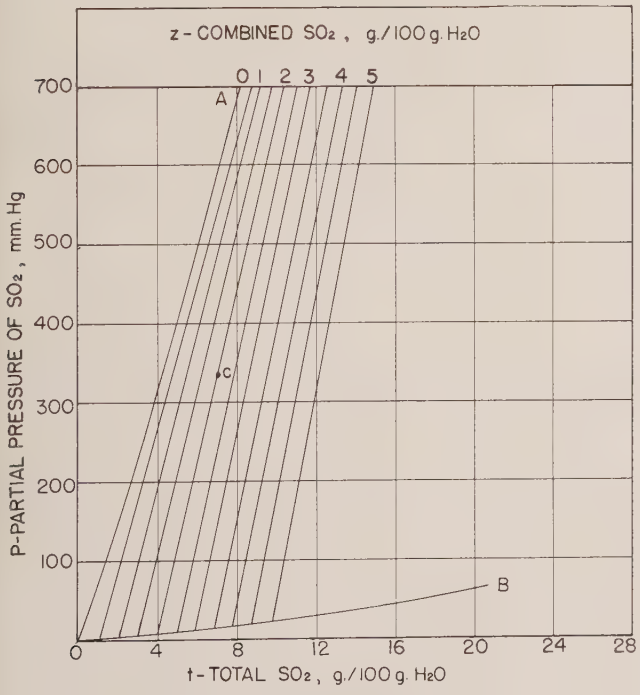

Fig. 2. p-t-z Diagram for 25°C.

Since Smith and Parkhurst (*8*) measured the solubility relationship in the unsaturated region experimentally and concluded that the lines of constant

line at a high partial pressure of SO_2. The method used to locate the constant combined lines in the

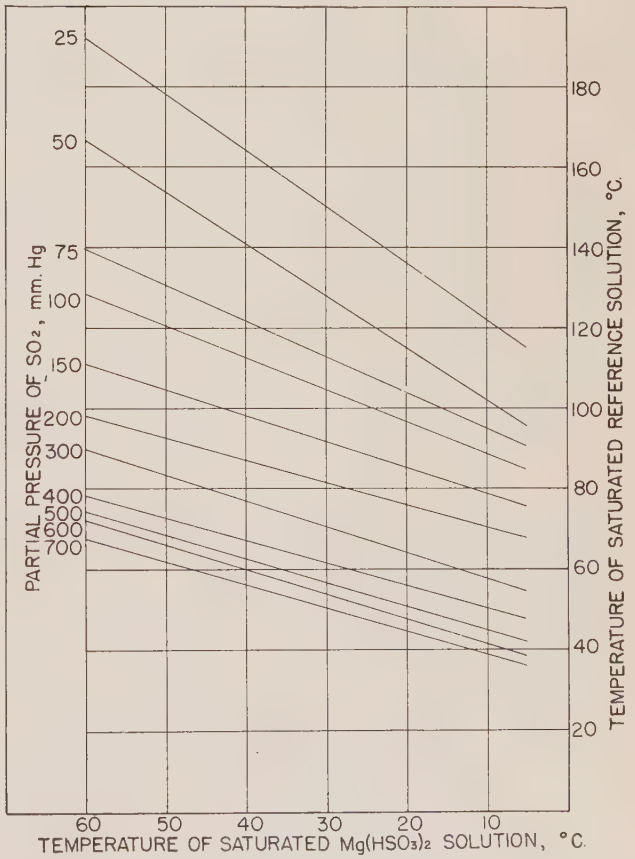

Fig. 3. Duhring diagram for $Mg(HSO_3)_2$ solutions

earlier article for the calcium system (*4*) could not be used as the ratio of t/z was always less than 2 for the magnesium system.

The lines of constant combined sulphur dioxide are drawn only above and to the left of the curve OB as this is the unsaturated region and the area below OB represents a supersaturated or unstable region. In the unsaturated region the constant combined lines may be represented by the equation:

$$p - p_s = k(t - 1.95z)$$

where

p = partial pressure of sulphur dioxide in equilibrium with the solution
p_s = partial pressure of sulphur dioxide in equilibrium with a saturated solution for a chosen amount of combined SO_2
t = total sulphur dioxide in solution
z = combined sulphur dioxide
$t - 1.95z$ = sulphur dioxide equivalent to the free sulphurous acid in solution
$t - z$ = free or available sulphur dioxide
k = slope of constant combined lines except the line for $z = 0$

This equation represents all combined lines except the line for $z = 0$ which was drawn from solubility data for sulphur dioxide in water (7). The slope of the various combined lines is not constant but is a function of temperature and to some extent of the concentration of the combined SO_2.

One use of the p-t-z charts would be to find the partial pressure of sulphur dioxide above a solution of known total and combined sulphur dioxide. Assume the solution analyzed $t = 7.0$ and $z = 2.0$ grams of SO_2 per 100 grams of water. The partial pressure of SO_2 exerted by this solution at 25°C. would be obtained by entering Fig. 2 with $t = 7.0$, then proceeding vertically until the line for $z = 2.0$ was intersected (point C, Fig. 2). The partial pressure of SO_2 would be read as 335 mm. Hg.

Duhring's Rule was applied by Conrad and Beuschlein (4) to obtain solubilities at temperatures other than those at which data were available for the calcium bisulphite system. Figure 3 is a similar Duhring

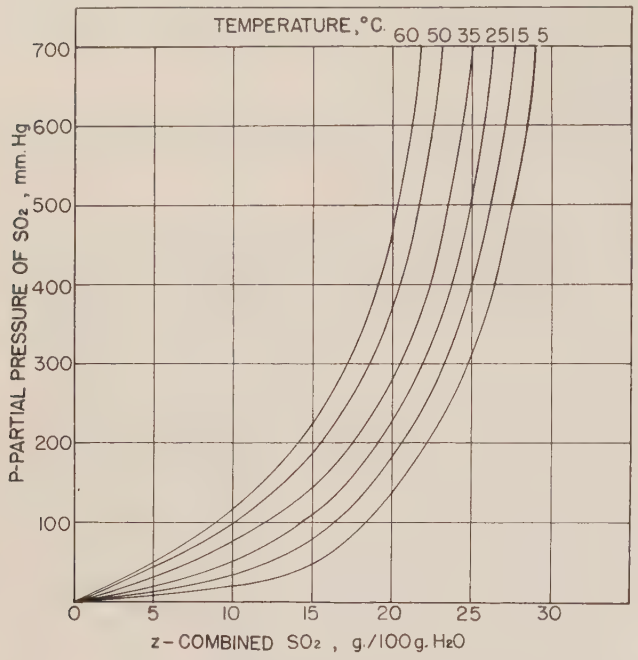

Fig. 4. Sulfur dioxide pressure of saturated magnesium bisulphite solutions

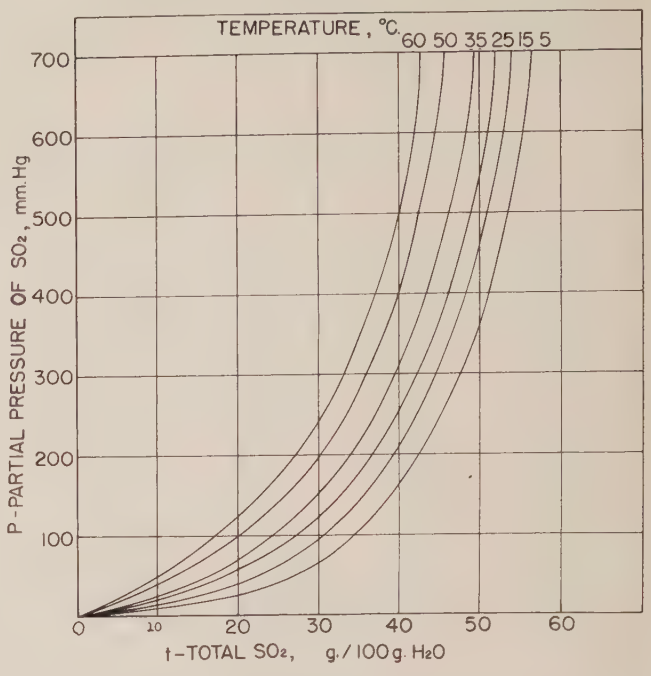

Fig. 5. Sulphur dioxide pressure of saturated magnesium bisulphite solutions

Table II. Data for Equilibrium Curves of Saturated Magnesium Bisulphite Solutions

	Grams per 100 grams H_2O																	
	5°C.[a]			15°C.[b]			25°C.[b]			35°C.[a]			50°C.[a]			60°C.[a]		
Pressure, SO_2, mm. Hg	*Total SO_2* t	*Free SO_2* t − z	*Combined SO_2* z	*Total SO_2* t	*Free SO_2* t − z	*Combined SO_2* z	*Total SO_2* t	*Free SO_2* t − z	*Combined SO_2* z	*Total SO_2* t	*Free SO_2* t − z	*Combined SO_2* z	*Total SO_2* t	*Free SO_2* t − z	*Combined SO_2* z	*Total SO_2* t	*Free SO_2* t − z	*Combined SO_2* z
700	56.5	27.5	29.0	54.0	26.3	27.7	52.0	25.6	26.4	49.4	24.3	25.1	45.9	22.7	23.2	42.9	21.1	21.8
600	55.4	27.0	28.4	52.9	25.8	27.1	51.0	25.3	25.7	47.9	23.6	24.3	43.9	21.7	22.2	41.0	20.2	20.8
500	53.6	26.1	27.5	51.1	24.9	26.2	49.2	24.2	25.0	46.5	22.9	23.6	42.5	20.9	21.6	40.1	19.7	20.4
400	51.2	24.8	26.4	48.4	23.5	24.9	46.5	22.7	23.8	43.8	21.3	22.5	40.4	19.7	20.7	37.8	18.4	19.4
300	47.6	22.8	24.8	44.7	21.4	23.3	42.0	20.1	21.9	39.2	18.8	20.4	35.0	16.8	18.2	32.2	15.4	16.8
200	41.9	20.1	21.8	39.5	19.1	20.4	36.5	17.2	19.3	34.4	16.3	18.1	30.8	14.6	16.2	28.8	13.8	15.0
150	38.6	18.5	20.1	35.7	17.1	18.6	32.7	15.5	17.2	29.6	14.0	15.6	25.3	12.0	13.3	22.6	10.8	11.8
100	34.6	16.6	18.0	30.9	14.7	16.2	26.9	12.5	14.4	23.4	11.1	12.3	18.0	8.5	9.5	14.6	6.9	7.7
75	32.5	15.6	16.9	28.2	13.5	14.7	22.8	10.4	12.4	19.2	9.1	10.1	14.6	6.9	7.7	11.6	5.5	6.1
50	29.6	14.3	15.3	23.7	11.4	12.3	17.8	8.3	9.5	13.1	6.2	6.9	7.6	3.6	4.0	5.7	2.7	3.0
25	20.6	9.9	10.7	15.0	7.0	8.0	10.6	5.1	5.5	7.0	3.3	3.7	4.8	2.3	2.3	4.1	2.0	2.1

[a] Calculated by Duhring's Rule. [b] Smoothed experimental data, Conrad, F. H., and Brice, D. B. (5).

Rule diagram for magnesium bisulphite. The temperature of the magnesium bisulphite solutions was plotted against the temperature at which two hundred times the solubility of calcium hydroxide was the same as the solubility of the combined SO_2. Since solubilities of combined SO_2 were available at 15 and 25°C. this gave a straight line at any chosen pressure.

Values of combined sulphur dioxide were then read at chosen temperatures for each Duhring line drawn and plotted as predicted solubility curves in Fig. 4. The curves at 15 and 25°C. are curves of smoothed experimental data, while the others are the predicted curves.

Total sulphur dioxide solubility curves (Fig. 5) were obtained by multiplying the values of combined SO_2, z, by the ratios of t/z shown in Table I. The points used in plotting Figs. 4 and 5, are tabulated in Table II, along with values of the free SO_2 $(t - z)$. In the original data the measured pressure was the total pressure of SO_2 plus water vapor. Partial pressures of SO_2 were obtained by subtracting the vapor pressure of water at the particular temperature from the total pressure. This introduces a small error as it does not allow for the vapor pressure lowering of the dissolved substances. A trial calculation showed that this would introduce an error of not over 0.3% in the partial pressure of SO_2.

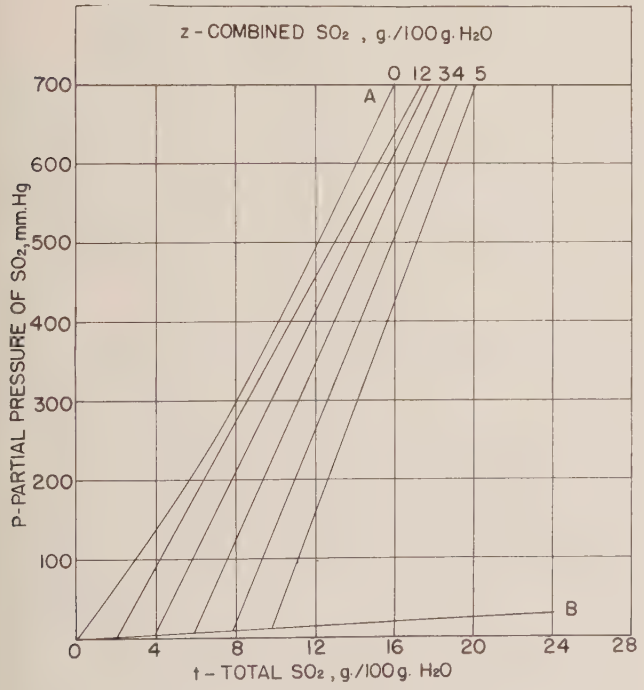

Fig. 6. p-t-z Diagram for 5°C.

The p-t-z diagrams at 5, 35, 50, and 60°C. are based on this extrapolated data combined with data from Smith and Parkhurst's work. They were constructed in a manner similar to Figs. 1 and 2 and are shown as Figs. 6, 7, 8, and 9.

The reliability of the data read from the Duhring Rule diagram is enhanced by the single determination at 35°C. and 728.7 mm. of Hg total pressure or 686.5 mm. Hg partial pressure of SO_2. Table III shows a comparison for this single point.

Table III

	Grams SO_2 per 100 grams H_2O	
	Observed	*Calculated*
Total	50.1	48.8
Free	24.4	23.8
Combined	25.7	25.0

A comparison of some of the data of Smith and Parkhurst (*8*) at 20°C. and 366.6 mm. of Hg with interpolated values taken from Figs. 1 and 2 is given in Table IV.

Table IV. Comparison of Calculated and Experimental Solubilities of SO_2 in $Mg(HSO_3)_2$ Solutions

Combined SO_2, grams per 100 grams H_2O z	*Total SO_2 grams per 100 grams H_2O Conrad and Brice calculated*	*Smith and Parkhurst experimental*[a]	*Difference*	*Per cent deviation*
0.64	6.05	5.96	+0.09	+1.51
1.20	6.82	6.71	+0.11	+1.64
1.92	7.88	7.99	−0.11	−1.39
2.57	8.88	8.84	+0.04	+0.45
3.21	9.88	9.92	−0.04	−0.40
			Average deviation	±1.08

[a] Smith and Parkhurst results originally reported in grams per 100 ml. of water. Recalculated for comparison.

Clarke (*2*) has determined vapor pressure data in the two-phase or unsaturated region for the magnesium system. The range covered is up to 6.49 combined and 12.79 total SO_2. The units are grams per 100 ml. of solution. The pressures ranged up to 1100

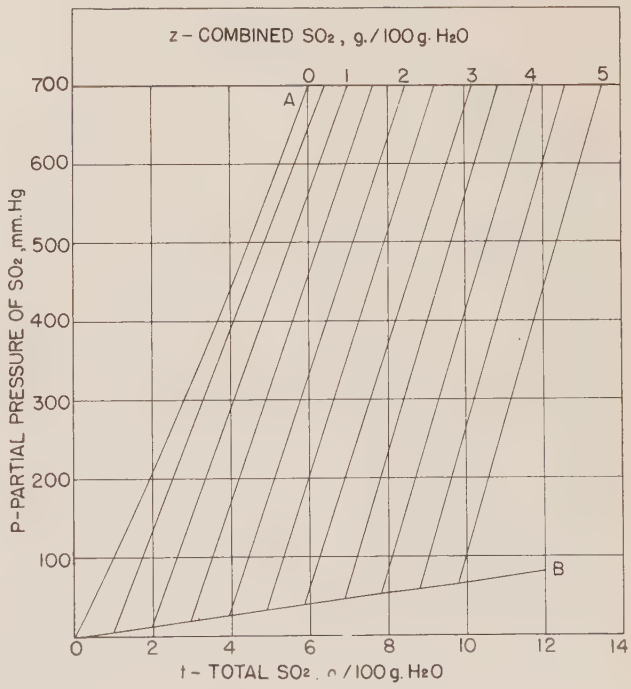

Fig. 7. p-t-z Diagram for 35°C.

mm. of Hg in some cases. Since there are very little data on the specific gravities or densities of magnesium bisulphite solutions, an exact comparison is impossible. It is possible to compare the predicted data of this paper with that of Clark (*2*) qualitatively if two assumptions are made. These two assumptions will establish the extremes of difference or deviation between the two sets of data. The assumption that 100 ml. of solution contained 100 grams of water was made and sixteen different points were calculated and compared. This gave an average deviation of ±2.77%. A second assumption that 100 ml. of solution weighs 100 grams was made and the calculation

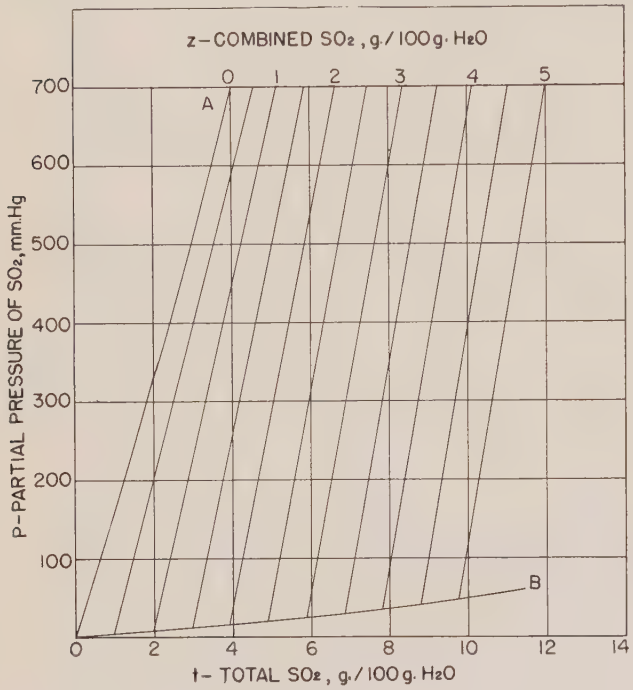
z – COMBINED SO₂, g./100g. H₂O
0 1 2 3 4 5
A
B
P – PARTIAL PRESSURE OF SO₂, mm. Hg
100 200 300 400 500 600 700
0 2 4 6 8 10 12 14
t – TOTAL SO₂, g./100g. H₂O

Fig. 8. **p-t-z *Diagram for 50°C.***

repeated. This gave an average deviation of ±4.51%. The true average deviation would lie between 2.77 and 4.51% since 100 ml. of any of these solutions would weigh more than 100 grams and contain less than 100 grams of water.

White, Vivian, and Whitney (*9*) have recently investigated the two-phase (gas and liquid) region for the calcium system and have compared their results with the results of other workers in the field. These authors state: "the close agreement with the results of Conrad and Beuschlein (*4*) is notable."

Examination of the *p-t-z* diagrams, particularly those at 5 and 15°C., indicates that possibly the constant combined SO_2 lines should be slightly curved for low concentrations. The curves for the solubility of SO_2 in water are slightly curved and one would also expect a slight curvature in the combined lines. Clarke's (*2*) original data, at 25°C., were recalculated to observe if any curvature could be detected, but no curvature was evident. A plot of the data of Beazley (*1*) for the calcium system, at 25°C., in the form of a *p-t-z*, diagram does show such a curvature.

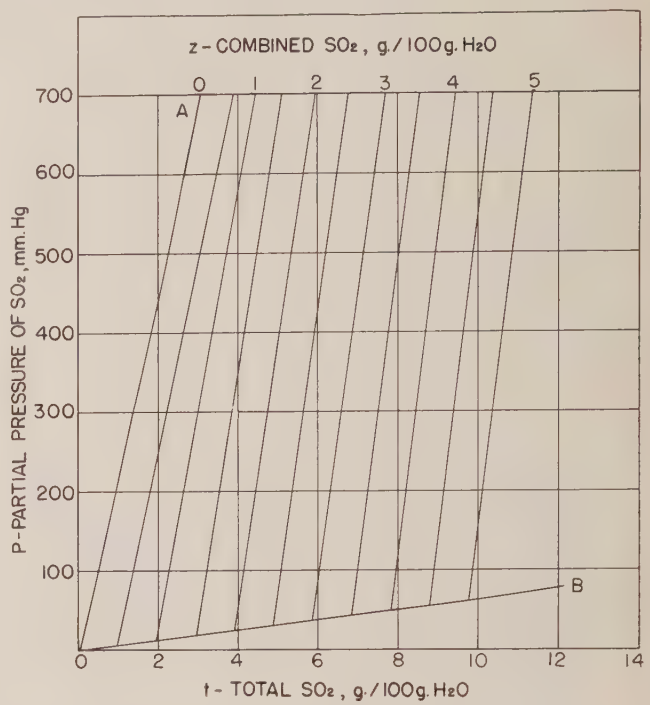
z – COMBINED SO₂, g./100g. H₂O
0 1 2 3 4 5
A
B
P – PARTIAL PRESSURE OF SO₂, mm. Hg
100 200 300 400 500 600 700
0 2 4 6 8 10 12 14
t – TOTAL SO₂, g./100g. H₂O

Fig. 9. **p-t-z *Diagram for 60°C.***

The Duhring relation has been applied to give solubility data which should prove satisfactory to describe both saturated and unsaturated solutions of magnesium bisulphite from 5 to 60°C., and at partial pressures of SO_2 up to 700 mm. Hg. The comparisons given in Tables III and IV indicate the reliability of the method.

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Preservation of Groundwood Pulp During Storage

B. F. SHEMA

The results of a mill trial in which two disinfectants, Santobrite and Lignasan, were used in an attempt to prevent degradation of groundwood caused by microorganisms are presented. The agents at various concentrations were applied to the pulp on a lap machine. The stock was then stored and examined periodically. It appears from this particular trial that no less than 0.14% (by weight) Santobrite must be retained by the pulp for effective results. The data for Lignasan were inconclusive due to an error.

Groundwood pulp is the most susceptible of all pulps to attack by microorganisms. With the exception of most of the water-soluble portion of the wood, groundwood pulp contains all the components in wood. This pulp is only partially sterilized during grinding and it quickly becomes recontaminated after it leaves the grinders. Many kinds of bacteria and fungi find groundwood pulp an excellent source of food. Whether or not these microorganisms attack the groundwood pulp to any extent depends largely upon the following conditions: (1) the time lag between grinding and incorporation of the pulp into paper, (2) the application of effective chemical disinfectants to the freshly ground pulp, (3) the temperature at which the pulp is stored, and (4) moisture content of the pulp during storage.

Some paper companies have closely integrated pulp manufacture with papermaking. In such cases, the time lag at all seasons of the year between grinding the wood and incorporating the pulp into paper is too short to allow serious deterioration or staining of groundwood pulp. No pulp storage problem exists in these mills, because pulps are made only as fast as they are needed for papermaking.

On the other hand, there are groundwood mills which depend upon irregular pulpwood supplies as well as upon irregular water power. In some cases, a much greater tonnage is ground during winter months when water levels are at their maximum than during summer months. A real need for minimizing damages to groundwood pulp during storage exists in such mills. A case in point is the growth of a fungus in stored lap pulp to such an extent that all of it must be rescreened before it is usable for papermaking. The growth causes clumps of fibers to adhere so firmly that the usual beating cycle is unable to disintegrate the fibers.

Scandinavian pulp mills have pioneered in the preservation of lap pulps including both groundwood and chemical types. In part, the preservation is dependent upon a very low moisture content which is unfavorable for the growth of microorganisms. In part, it is dependent upon the introduction of effective chemical disinfectants. Ethylmercury phosphate (and also the chloride) has been successfully used according to Rennerfelt [Särtryck ur Svenska Skogsvards Foreningens Tidskrift, 1941, Häfte 1 (English translation by W. Johansson)], who made laboratory studies of a considerable number of such materials and mill studies with the more promising ones.

During the fall of 1945, The Institute of Paper Chemistry made plans to initiate a series of groundwood lap preservation tests in a mill which is located near Appleton. Arrangements were made with this mill to construct the necessary equipment for treating the lap made on one machine. Monsanto Chemical Company and E. I. du Pont de Nemours & Company, Inc., supplied sufficient amounts of Santobrite and Lignasan, respectively, to carry out the tests. Three concentrations of each material were applied to approximately 4-ton lots of groundwood pulp which was then stored directly above untreated lap in the warehouse for pulp storage. The details of these tests and the observed effects after 3, 6, 9, and 12 months of storage are described in this article.

PROCEDURE

The Santobrite and Lignasan were dissolved in large wooden tanks, agitation being supplied by a Lightnin' mixer. This mixer was used only when the solutions were prepared in order to prevent excessive foaming. The tanks served as reservoirs and supplied the solution to 50-gallon wooden barrels. The barrels were maintained at a constant level with a float valve thus giving a constant head which eliminated as much as possible erratic flows. The feed line to the lap machine consisted of a perforated pipe extending over its entire length. The solution dripped from this pipe onto a wooden miter roll which rested on the top press roll thus giving an even distribution over the pulp as it was being formed. In order to further facilitate the distribution of the toxicant on the miter roll, a piece of felt was placed against this roll thus preventing excessive channeling of the solution. The rate of flow was maintained at about 1850 ml. per minute. In order to obtain different concentrations of toxicant on the lap, it was necessary to change the concentration of the solution being applied. Therefore, for this study, three different concentrations of Santobrite and Lignasan were used—0.25, 0.5, and 0.75% for Santobrite and 0.15, 0.25, and 0.5% for Lignasan (all concentrations based on percentage by weight). About 4 tons of pulp (dry basis) were treated with each concentration. These lots were then stored on the top of untreated piles.

At the time that each treatment was being applied, samples of lap were obtained and analyzed for the amount of Lignasan and Santobrite retained. About 75 to 80% of the material applied was retained in the

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lap; the remainder probably was lost through the white water as samples of this showed the presence of some of the toxicant. The analysis for Lignasan was based on mercury and that for Santobrite on pentachlorophenate. The data are given in Table I.

Table I. Retention of Lignasan and Santobrite in Treated Groundwood Lap

Toxicant	*Concentration of solution applied, % (by wt.)*	*Retention of toxicant in the groundwood lap, % (by wt.)*
Lignasan	0.15	0.16
	0.25	0.19
	0.5	0.24
Santobrite	0.25	0.14
	0.5	0.17
	0.75	0.54

Treatment began on March 11, 1946, with the 0.75% concentration of Santobrite. On March 13, 0.5% Santobrite was used and on March 15, 0.25% Santobrite was applied. Between treatments with Santobrite and Lignasan, the system was thoroughly washed and on March 18, 0.25% Lignasan, on March 20, 0.5% Lignasan, and on March 21, 0.15% Lignasan was applied.

RESULTS

The stored lap stock was examined at periodic intervals. At the end of 2 months' storage, the Lignasan-treated lap showed some growth of fungi along the exposed edges of the pile; however, the Santobrite-treated stock was clean. At the end of 3 months' storage, none of the treated lap stock was severely molded although a few spots were beginning to appear

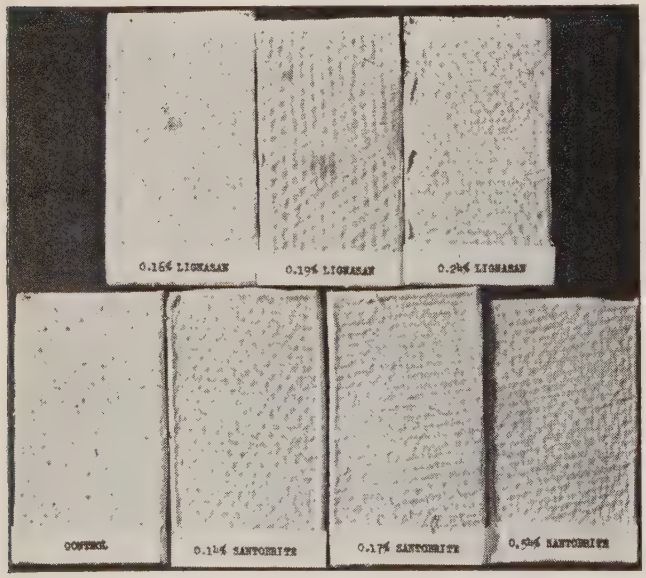

Fig. 2. Appearance of groundwood lap after 6 months' storage

on the pulp treated with the two lower concentrations of Lignasan; however, these spots were not as typical as those found on the controls. The areas were large, but the color was not as deep brown as the controls nor was the pulp matted together. The Santobrite-treated pulp was free of any spots (Fig. 1). The control showed many spots and, in many cases, was seriously discolored by the presence of other fungi. At the end of 6 months, the effect of the treatment was more pronounced than at the end of 3 months. The control was seriously spotted and discolored by the presence of other fungi. The pulp treated with the lowest concentration of Lignasan showed a few brown specks, but it was not seriously discolored by other fungi; the outer portion of the pile was discolored, but this did not extend into the pile. The pulp retaining 0.19% Lignasan showed a few brown spots but these were not typical brown specks. The pulp treated with the highest concentration of Lignasan was comparatively clean although, in a few cases, some large spots were observed. The Santobrite-treated lap was clean (Fig. 2). After 9 months,

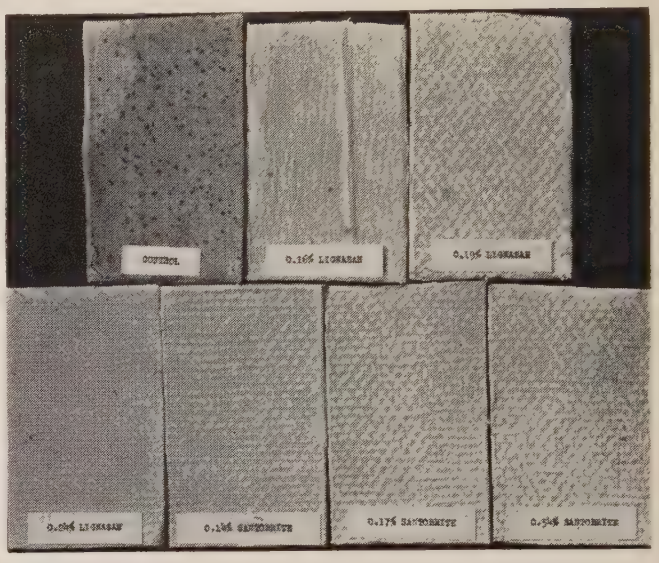

Fig. 2. Appearance of groundwood lap after 6 months' storage

there was no significant change in the observations made at the end of 6 months.

The organism causing this brown spot in the pulp was tentatively identified as an *Oidium sp.* with a relatively high degree of resistance to the organic mercurials.

In the earlier examinations of the piles, no attempt was made to examine the pile to any great depth because it was thought best not to disrupt the pile until at the end of 1 year of storage. At this time, a portion through the center of each treatment was removed. It was not possible to obtain data for the Lignasan-treated portion of the experiment because, through an error, this portion of the lap had been removed; however, data were obtained for the Santobrite-treated pulp. The two highest treatments gave excellent pulp in that no spotting was observed; the pulp with the lowest content of Santobrite showed a few isolated spots but many of the laps were clean. Therefore, it appears that this is the lowest limit to be used in this particular mill.

The present cost of the treatment (toxicant only) with the lowest concentration of Santobrite at this mill would be from 90c to $1 per ton.

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Felt Length Measurement Using the Kenwood Wheel

IRVING H. PETERS

When a papermakers' felt runs on a board machine where the felt must act as a power transmission device, it changes in length by an amount dependent upon the load to which it is subjected. The Kenwood wheel is an instrument for measuring the felt elongation which affects operation and felt life. Excessive stretch is defined and suggestions for reducing stretch are given. Examples are given to show how manipulation of the drives can change the amount of stretch obtained. The felt length measurement is the only means of easily and accurately indicating loads applied to a felt. The use of this type of measurement becomes even more important on machines where electrical drives are employed than it has been on machines having older type drives.

THE PURPOSE of this paper is to discuss and analyze the phenomenon of the felt length measurement, especially as applied to bottom board felts.

The fact that a woven woolen papermakers' felt will change in length by an amount proportional to the magnitude of the load to which it is subjected, provides a useful operating tool that makes it possible to gather certain information which would otherwise be very difficult, if not impossible, to obtain. On a board machine where the felt must pull numerous frictional loads, the felt will elongate after each one of these load points. By "load point" is meant the cylinders, the primary presses, the squeeze rolls, and the suction boxes.

Practically, felt length measurements can be made on a running felt by means of a simple device known as the Kenwood wheel (see Fig. 1). This instrument

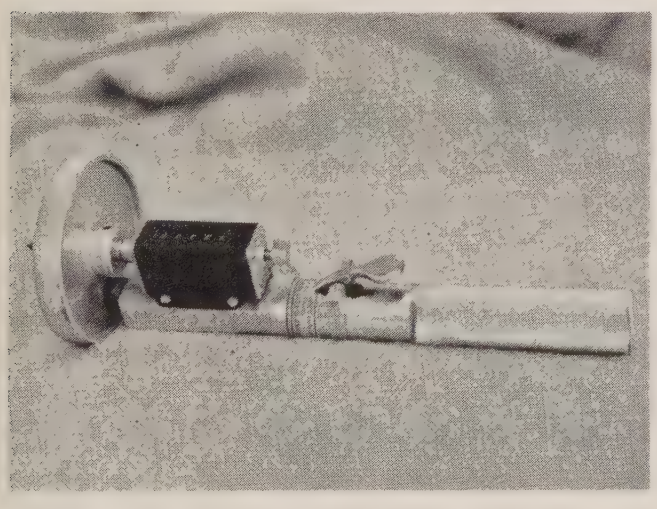

Fig. 1. The Kenwood wheel

consists of an aluminum wheel having a circumference of exactly 1 foot. The wheel is attached to a Veeder-Root revolution counter, and the instrument is provided with a suitable brake to stop the motion of the wheel instantaneously. One revolution of the wheel indicates 1 foot of felt travel on the revolution counter. The revolution counter reads in feet and tenths of feet.

In order to make a felt length measurement, the wheel is placed upon the running felt at a time when the blue line in the felt passes by the location where the measurement is to be made. The wheel is kept on the felt until the blue line makes one complete circuit of the machine and again passes under the wheel.

Figure 2 is a diagrammatic sketch of a cylinder board machine showing the bottom felt only. If it is

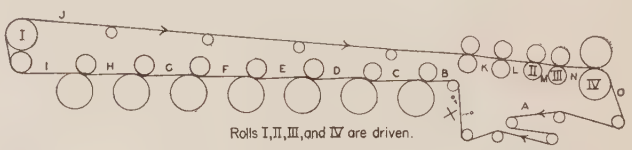

Fig. 2. Diagrammatic sketch of typical board machine

desired to know what the running length of the bottom felt is at point A, for example, it is only necessary to place the measuring wheel upon the blue line as it passes point A, start the foot counter, and stop and remove the measuring wheel after the blue line again passes point A. The same type of measurement can be made at points B, C, etc. If this is done for all the points indicated in Fig. 2, a felt running length will be obtained at each of these positions. These running lengths can be plotted on a graph and together are called the stretch curve.

Actually a point on the felt travels farther when the measurement is started and stopped at point B rather than at point A. It takes the same time, however, for the felt to make one complete revolution regardless of the starting and stopping point. Since the point on the felt travels farther in the same time when traveling from point B back to point B than from A back to point A, the felt surface speed at point B is greater than at point A. Figure 3 is a plot of a stretch curve made on the machine represented diagrammatically in Fig. 2.

The difference in felt length from point B to point C represents the amount of frictional load to which the felt is being subjected by the cylinder mold between these two measuring points, and so on.

The curve of felt elongation against load for a woven woolen felt, while not absolutely a straight line, is close enough in the range of interest so that for all practical purposes the above statement is true. It is very important, however, from the standpoint of felt life to run felts as slack as possible. The closer the running length of the felt approaches the elastic limit of the felt, the more rapidly yarn and fabric degradation occur.

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EXCESSIVE LOADS ON FELTS

After the stretch curve has been determined, there is the problem of just how much stretch constitutes an excessive load on the felt. This is a matter which necessitates judgment and experience, taking into account the particular design of felt involved, the conditions of load distribution, and also the temperature at which the felt is required to operate. There are, however, some general observations that can be made about the magnitude of excessive stretches from observations on all driven board machines. It is known, for example, that it is generally necessary to have the bottom felt elongate an amount in the order of 0.1 to 0.2 of a per cent of stretch at each cylinder and primary press in order to maintain sufficient felt tension to prevent operational troubles such as blowing and checking. This slight elongation seems to be necessary also in order to keep the felt clean. This then would be the minimum amount of stretch that is practical. Everything above the minimum, of course, is not excessive. Machines have been measured where the total stretch on a 150-foot felt has been 6 feet or more for approximately fifteen positions and there was no evidence of stretching and narrowing. On the other hand, machines have been seen where the total stretch was about 5 feet and the felts were literally "walking off the machine." The difference, of course, is that in the first case the stretch curve was found to contain no points where a large load was being applied at one position. In fact, there was no load of over 0.7 feet or about 0.5% of 1 foot and most of the loads were 0.3 to 0.4 of 1 foot. In the second case, there were single loads of over 1 foot. Where temperature is high and finish requirements call for a felt of relatively less warp strength, it has repeatedly been found that stretches of 1 foot or over could certainly be considered excessive.

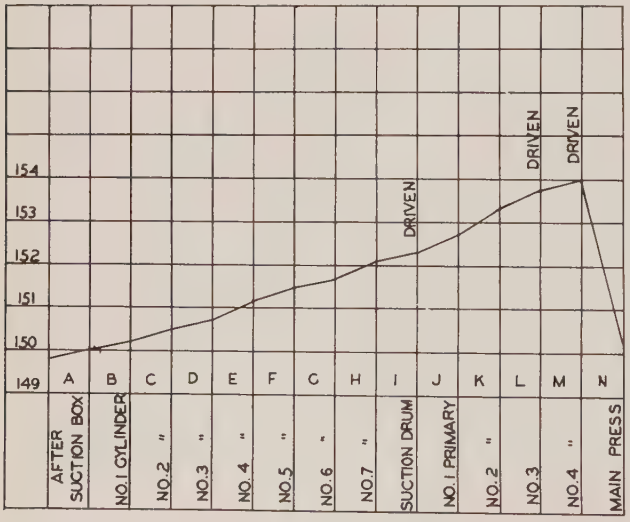

Fig. 3. Stretch curve

From experience, it has been observed that a good rule to follow is to look for trouble when a felt stretch of over 0.5% is indicated. Occasionally, a machine is found with single felt stretches in the order of 2 feet and "pulls" of 3 feet have even been found. Of course, in these cases the felts were giving very short life and were stretching and narrowing.

The stretching and narrowing and the excessive frictional wear on a felt are the result of more than just the total load impressed upon the felt as represented by the total stretch but are the result of the rate of that load application. The total effect of one stretch of 1 foot in length is much greater in the tendency it produces in the felt to stretch and to run a shorter time on the machine than are two stretches of 0.5 of a foot each. This is because the impact of the 1-foot stretch is greater than that of two 0.5-foot stretches.

REDUCTION OF EXCESSIVE STRETCH

There are many things that can be done to reduce excessive stretches. Where there are no electric drives, the stretches may be reduced on cylinders by lubricating bearings better, loosening collars, by making sure that clearance between the chime of the cylinder and the sealing ring are not too great, and that alignment here is good. In fact, anything which necessitates running collars tight should be eliminated. Usually most of the resistance to turning of the cylinders is contributed by the collars, although tight, misaligned, broken, or poorly lubricated bearings are also a major cause of felt elongation. Of course, there is one force that cannot be eliminated or reduced without driving the cylinders and that is the resistance that the stock in the vat offers to the turning of the cylinder. If machine speeds are increased, the friction load on the felt, of course, increases.

Excessive stretch on undriven primary presses can generally be reduced by proper attention to the bearings, to weighting the presses, and to alignment. The use of antifriction bearings has been the greatest single help toward reducing excessive stretch at these points. Incidentally, it is more important from a standpoint of reducing felt stretch and improving felt life to have antifriction bearings on all undriven primary press positions than to have them on cylinder molds. The weight on primary press bearings is usually much greater than that on cylinder mold bearings, and the driving radius of the primary press rolls is smaller than that of the cylinders.

The operation of helper drives on primary press rolls, whether they be mechanical or electrical drives, is perhaps the most important consideration with respect to reduction of individual felt stretches or reduction of "bad pulls" as they are sometimes called. The helper drive is designed to take some of the load off the main press drive and must do just this in order to properly perform its function. The felt length measurement again is the only accurate indication of how much power is required by a helper drive for its proper operation. Referring again to Fig. 2, a measurement after the No. 2 primary and a measurement after the No. 3 primary press or a measurement at position M and a measurement at position N will indicate how the helper drive is operated on this press. With this drive, the friction of the No. 3 primary must be overcome and, if possible, the No. 4 primary helper drive and the main press drive assisted in pulling the machine. The best settings for these drives are those which actually produce the lowest individual stretches through these positions and which result in the lowest total stretch.

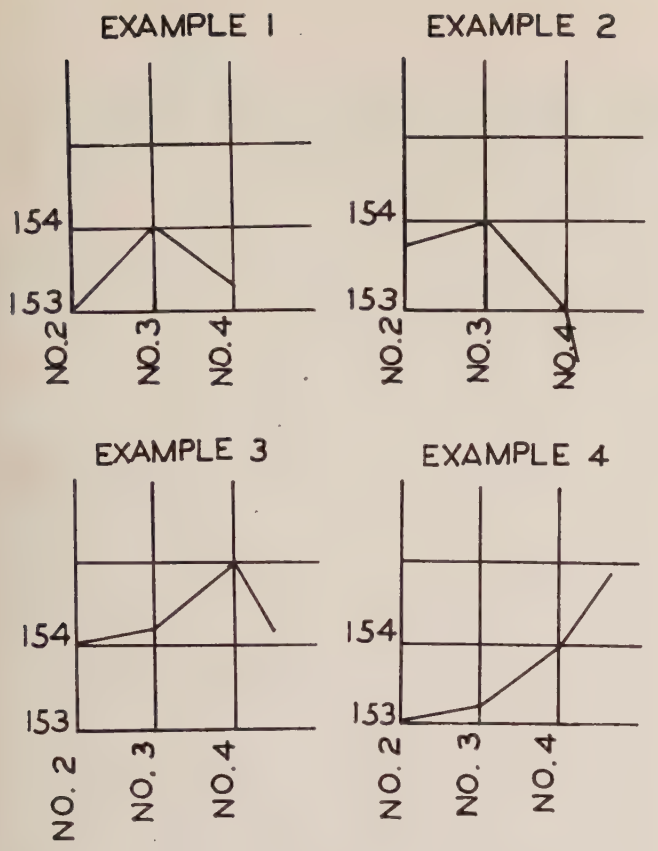

Fig. 4. Types of stretch curves obtained with helper drives

The stretch curve in Fig. 3 indicates a typical case. In Fig. 4 examples 1, 2, 3, and 4 indicate other possible shapes of the stretch curve that can be obtained by merely changing the way in which the helper drives are operated. In order to flatten out the curve in example 1 and make it so that the load distribution on the helper drive is more uniform, more power must be put into the No. 3 primary. This will reduce the felt length as measured after the No. 3 primary. In this particular case, it is best to tighten up on the No. 3 primary helper drive rather than to slacken up on the No. 4 primary helper drive because the felt length change between the points L and M is so large. In example 2, however, it would be necessary to slacken up the No. 4 primary helper drive. In this case, the No. 4 helper drive is not only overcoming all the frictional load on No. 4 primary press but is actually assisting the main press in driving the rest of the machine. This is a condition which is desirable from the standpoint of reducing the total stretch of the machine; however, it is sometimes difficult to operate in this manner, especially on heavy weight boards where the sheet is rather wet entering the main press. When operating the drives so that a stretch curve of this shape is produced, the tendency is to get checking unless the sheet as it enters the main press is dry enough. In example 3, the remedy would be to tighten up the No. 4 helper drive. In example 4, both the No. 3 and the No. 4 primary helper drives should be tightened.

ELECTRICALLY DRIVEN BOARD MACHINES

On electrically driven board machines where all or most of the major loads on the machines are controllable, it is possible to eliminate almost entirely the tendency for the felt to change in length. When these drives were first installed, it was thought that it would be desirable to do just this. However, it has been found that it is necessary from a standpoint of operation to have the felt elongate as it runs about the machine. This elongation should be in the order of 0.1 to 0.3 of 1 foot for each load point on a 150-foot felt and can, and should be, kept at the minimum. Slight elongation of the felt is necessary to maintain openness.

The advent of electric drives does not obviate the necessity of relying on the elastic property of the felt for the setting of these drives. If anything, it makes the measurement of felt lengths even more important. The power input to each individual drive on a board machine does not indicate anything about the total frictional load present. The important thing so far as operation is concerned is to know how much frictional load remains after part has been removed by the electrical helper drive. This is the amount that is responsible for elongating the felt. Since frictional loads on board machines are constantly being changed, there is no way of knowing what these frictional loads are other than by taking a felt length measurement. Changes in speed and caliper are not the only factors that cause tension load changes but, for example, collar tensions on cylinders are adjusted every time the machine is down for a felt change. Power input to motors with change in speed is, of course, taken care of in the drive. If a wide variety of calipers is to be run, it is best to establish the best drive setting for each caliper by use of the length measurement.

The fact that the reduction of felt stretches on a cylinder board machine will result in improved felt life has been proved time and time again. It is needed only to cite the effect on felt life that electrical drives can have. In the bulk of cases where electrical drives have been used, there has been an improvement in felt life. More attention to felt length changes on this type of machine can result in still further improvements with more consistent results. There is a mill which had been taking these felt stretch readings daily. After about nine running days, they noticed a very sharp increase in the stretch after the drum roll. This stretch changed from about 0.5 of a foot to 1.5 feet. Thinking perhaps it was a dry bearing, the whole machine was oiled thoroughly and again a stretch curve was taken. A drop in the stretch curve all along the machine up until the drum roll where the change in length was about the same as it had been or about 1.5 feet was noticed. An investigation of the bearings on this roll showed that there was a broken ball bearing. This bearing was replaced and the curve returned to its original condition.

The intelligent use of this type of measurement can result in better felt life and better operation.

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Measurement of Water-Vapor Permeability at Low Temperature

The Hygrometric Sweep Gas Method

W. A. WINK and LEONARD R. DEARTH

Because of the difficulties in the measurement of water-vapor permeability of vapor-resistant barriers at low temperatures by means of the gravimetric method, new equipment, based on the hygrometric sweep gas method, has been developed, and is described. The new method has been made possible by the recent development of very small, sensitive, and stable electric hygrometers. The sensitivity of the new method results from a combination of the inherent sensitivity of the hygrometric principle and the ability of the small electric hygrometer accurately to measure small changes in the relative humidity of the air passing over a specimen. The sweep gas method is of the steady-state class and is free of error at equilibrium arising in sorption effects. The sensitivity of the new method is sufficiently high that the length of time required to complete a test is limited only by the nature of the material, especially as the latter determines the time required for the specimen to attain equilibrium with the relative humidities of the air in contact with its two sides. The operation of the new equipment is illustrated by the performance on several samples of different types.

With the development and increased use of materials for the packaging of foods at low temperatures, the need for a suitable method for measuring the water-vapor permeability (WVP) of such materials has become urgent. The problems encountered and associated with the measurement of WVP at low temperatures have already been adequately discussed by Van den Akker (*1*), Cherepow (*2*), and in Instrumentation Reports to APPA (*3*). It is evident, on the basis of these discussions, that the determination of WVP at low temperatures (0°F. and below) is not necessarily accomplished with facility and reliability by the simple adaptation of a method which has been found to perform satisfactorily at normal room or elevated temperatures. An intrinsic difficulty in evaluating the WVP at a low temperature is attributed to the fact that the vapor pressure differential across the specimen is greatly reduced (for the same relative humidity differential) when going from normal room temperatures to, say, 0°F. Consequently, large reductions in the permeability values are also observed. It is therefore essential that the method employed to reliably evaluate the WVP at a low temperature must be capable of detecting an extremely small mass rate of transfer of water vapor.

In the consideration of a method for obtaining permeability data at low temperatures, it was believed that the hygrometric sweep gas method described by Van den Akker (*1*) possessed the required sensitivity and warranted development. This method, it will be recalled, takes advantage of a small but sensitive electric hygrometer for detecting the small quantities of moisture that would permeate a specimen having a good moisture-resistant barrier. The good sensitivity of the method is attributed to the fact that the mass of moisture permeating the specimen is evaluated in terms of its hygrometric effect. The significance of utilizing the hygrometric principle for the measurement of WVP is more fully appreciated when it is realized that at 0°F. only 1 microgram of moisture is required to change the relative humidity of 100 ml. of air by 1%. Since the recently developed electric hygrometers are capable of detecting changes in relative humidity of the order of a few hundredths of 1%, it is apparent that fractional parts of a microgram of moisture are easily detected.

This paper presents a detailed description of the equipment developed for obtaining permeability data at low temperatures in accordance with a recently proposed method (*1*). This method, designated the *hygrometric sweep gas method*, was first employed to evaluate the WVP of the samples included in the TAPPI round robin testing program, as sponsored by the Packaging Materials Testing Committee; the results obtained for these samples are presented later in this paper.

PRINCIPLE OF THE METHOD

The principle of the hygrometric sweep gas method is illustrated in Fig. 1. A specimen S is placed between two chambers in a test cell such that the opposite sides are exposed to different relative humidities. The space below the specimen is conditioned to a high relative humidity with a saturated salt solution and that above the specimen is swept with air conditioned to a low relative humidity. As moisture from the lower cham-

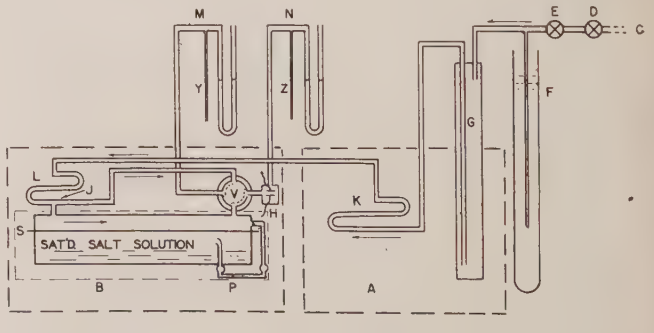

Fig. 1. Schematic sketch of apparatus for the hygrometric sweep gas method

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ber passes through the specimen and enters the upper chamber, the relative humidity of the air passing over the specimen is increased. This increase in the relative humidity is determined by means of the electric hygrometer H by obtaining the difference in the relative humidities of the air entering and leaving the space above the specimen. The volume rate of flow of the air is adjusted so that the relative humidity of the air leaving the upper chamber is maintained in a narrow range which is slightly above that of the incoming air. (A relative humidity differential of approximately 3% was employed to obtain the data presented in this paper.) Once the volume rate of flow and the difference in the relative humidities of the air entering and leaving the upper chamber have been accurately determined, the water vapor permeability (WVP) of the specimen is calculated in accordance with the following equation:

$$\text{WVP} = K(r_2 - r_1)\rho Q$$

where K is a known constant, r_2 is the relative humidity of the air leaving the space over the specimen, r_1 is the relative humidity of the air entering the space over the specimen, ρ is the density of saturated water vapor at the temperature at which the permeability measurement is made, and Q is the volume rate of flow of the air over the specimen.

The air which is conditioned to the low relative humidity is obtained from a compressed air line and enters the conditioning system at the point C. In order to provide a means for regulating the flow of air over the specimen, the air line is equipped with a pressure-reducing valve D which is adjusted to control the pressure at about 1 or 2 p.s.i., a needle valve E which is used as a manual control for adjusting the flow to approximately the desired value, and a manometer type of regulator F which serves as an additional means for ensuring a constant rate of flow. The regulator F simply consists of two long glass tubes (about 30 inches) having different diameters. The outer tube is filled with water to within a few inches of the top and the inner tube is arranged so that it can be raised or lowered in the water to any desired depth. To adjust the regulators for a given flow of air, the inner tube of the regulator F is set at an appropriate depth and the needle valve is then adjusted so that a small amount of air is caused to bubble out continuously at the lower end of the tube. The end of the tube is constricted somewhat to cause the air to leave in a stream of small bubbles.

The air leaving the regulators passes through a brass cylinder G (about 2 inches in diameter) and a coil of copper tubing K (0.5 inch in diameter and approximately 20 feet long) where it is cooled to the temperature of the bath A (this bath is controlled at the desired dew point temperature) and saturated with water vapor. The cylinder G is only partially immersed in the bath A and serves as a dehydrator, removing most of the excess moisture from the air before it enters the coil K. This method of removing the moisture is preferred to the use of drying tubes filled with a desiccant; the latter require considerably more attention and may possibly overdry the air before it enters the coil K. As the air flows through the coil of copper tubing L ($^1/_4$ inch in diameter and about 5 feet long) which is immersed in the bath B (this bath is controlled at the temperature desired for the permeability measurement), it is warmed to the temperature of the bath and enters the space above the specimen. The air entering this space has the partial pressure of water vapor in equilibrium with ice at the temperature of bath A and a relative humidity which, for this work, is given by the ratio of the vapor pressures over ice corresponding to the respective bath temperatures.

The stream of air conditioned to a low relative humidity divides equally at the point J so that half of the stream passes over the specimen and the other half flows directly to a four-way valve V. This valve is constructed in such a way that a 90° turn of the handle will direct the flow of air from either the upper branch from the point J, or from the space above the specimen, into the small chamber containing the electric hygrometer H. This valve arrangement provides a means for periodically checking the relative humidity of the incoming air without interfering with the flow of air passing over the specimen. When the valve is turned in the position indicated in the diagram, the air leaving the space above the specimen, of relative humidity r_2, is directed past the electric hygrometer. When the valve is turned through an angle of 90°, air of relative humidity r_1 flows past the hygrometer and an accurate measurement of the difference in the relative humidities is thereby easily obtained.

The rate of flow of air through the two paths from the point J is measured with two calibrated flowmeters M and N of the capillary-manometer type. In order to obtain the required sensitivity, these manometers are filled with oil (Amoil S) to which a small quantity of an oil-soluble dye has been added. The small capillaries Y and Z, through which the air exhausts into the atmosphere of the room, are and must be matched insofar as their resistance is concerned. By establishing conditions such that the resistance of the two paths of air beyond the point J are essentially the same, the valve V can be turned to either position without disturbing the rate of flow over the specimen. Furthermore, the pressures in the two lines are then also equal, which facilitates calibration of the hygrometer under conditions simulating those employed for the permeability measurements.

A small pressure equalizer P is utilized to avoid subjecting the specimens to a pressure differential whenever the temperature of the test cell is changed or whenever a change in the rate of flow is made. The equalizer consists of a small piece of glass tubing into which two small bulbs have been blown in the vertical sections that connect to the upper and lower chambers. The glass tube contains a small drop of Silicone oil which permits the pressures to equalize and yet prevents the transfer of water vapor from the lower to the upper chamber.

DESCRIPTION OF THE EQUIPMENT

Photographs of the permeability test cell are presented in Figs. 2 and 3. The view of the assembled cell (Fig. 2), as it appears prior to immersion in bath B, shows the location of the four-way valve V, the mounting for the electric hygrometer T, the coil L, and the

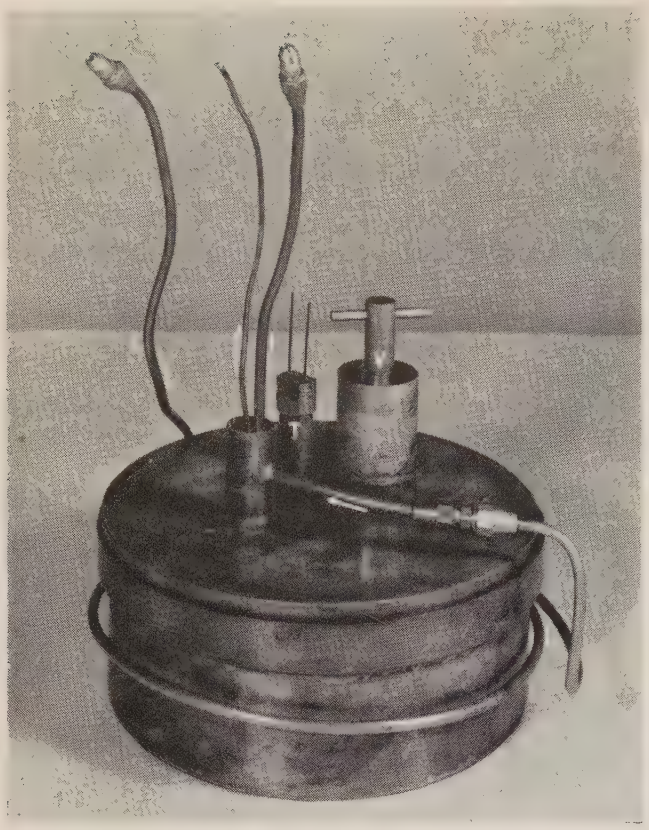

Fig. 2. View of assembled test cell

two outlet tubes which connect to the calibrated flowmeters M and N (Fig. 1). The outer container which serves as a means for preventing the bath liquid from coming in contact with the edge of the specimen is constructed of heavy gage copper.

The photograph in Fig. 3 shows the various components of the test cell as it appears when disassembled for changing a specimen. The lower chamber O contains four Petri dishes for holding the saturated salt solution. The inside diameter of the chamber is 8 inches and thus allows the testing of a specimen having an area of about 50 sq. in. The five small rods anchored to the edge of the chamber serve as supports for the specimen.

The upper chamber Q, through which the air conditioned at the low relative humidity passes, is equipped with a number of baffles. These baffles consist of short rods ($^1/_2$ inch long) having a diameter which is slightly less than the depth of the chamber ($^3/_{16}$ inch). The inner surface of the chamber is lightly coated with a microcrystalline wax which serves as a means for holding the baffles in place and also reduces the moisture adsorptive capacity of the chamber. The arrangement used for the baffles was determined by experiment in order to obtain a uniform distribution of the air passing over the surface of the specimen. In studying the air-flow patterns through the chamber, a moisture-sensitive dye was distributed over the surface of the chamber and sealed from the surrounding atmosphere with a glass plate. Moist air was then passed into the chamber at various and known rates of flow and the patterns assumed by the colored dye were observed. A number of trials, using various baffle combinations, were made to find the most satisfactory arrangement.

The tubes U and X are connected to the upper and lower chambers, respectively. The pressure equalizer (not shown) is connected to these tubes after the specimen has been inserted.

The test specimen is sealed to the outer edge of the two chambers with a grease and the chambers are held together with a sturdy yoke-type clamp. The upper and lower bars which form a part of this clamp make contact with the center of each chamber through a small steel ball so that the clamping load is uniformly distributed.

The outer container, with the flanged edge at the top, prevents the bath liquid from contacting the edge of the specimen. The narrow groove formed by the flange is partially filled with mercury which seals the cover to the lower container.

A detailed diagram of the mounting for the electric hygrometer is presented in Fig. 4. This mounting simply consists of a brass plug T which serves as the support for the small hygrometer H and the electrical leads W. The leads are small brass rods ($^1/_{16}$ inch in diameter) which are insulated with glass tubing R. Before mounting the hygrometer, the assembly consisting of the brass plug and the electrical leads is immersed in molten wax to vapor seal the holes through which the leads are brought. Finally, the leads and the glass tubing are securely anchored at the top with a hard sealing wax. The spring contactors anchored at the end of each lead hold the hygrometer in place and establish the electrical contact. The details for constructing the small glass hygrometer are presented in the paper by Van den Akker (*1*) and in reports to the American Paper and Pulp Association (*3*).

A description of the cryostats and of their controls is given in a report to the American Paper and Pulp Association (*3*).

Fig. 3. View of disassembled test cell

PROCEDURE

The procedure for evaluating the WVP of a sheet material at 0°F. with the two sides of the specimen exposed to relative humidities of 96 and 22%, respectively, is as follows: The test cell is disassembled as shown in Fig. 3. A saturated salt solution (NaCl), having an equilibrium relative humidity of 96%, together with an excess of the salt, is poured into the Petri dishes to a depth just sufficient to cover the bottom of each dish. A thin film of Celvacene (Distillation Products, Inc.) is evenly applied to the edges of the upper and lower chambers and a specimen previously cut to a diameter of roughly 8.5 inches is placed and centered over the lower chamber. The upper chamber is then placed over the specimen and clamped in place. The pressure equalizer is attached and the assembled cell is then placed in the outer container. The coil connection for the incoming air is made as shown in Fig. 2. The cryostats A and B are adjusted to maintain constant temperatures of −28.5 and 0°F., respectively.

Before placing the test assembly in bath B (0°F.), the coils L and K are connected and the space above the specimen is flushed with dry air obtained from coil K. (When the air from this coil is raised to normal room temperature, its relative humidity is extremely low.) This is done to eliminate the danger of condensing and freezing moisture in the air lines and the test assembly when they are placed in the bath. The flow of air must be maintained while immersing the assembly. To ensure adequate circulation and a uniform temperature of the liquid surrounding the test assembly, the assembly is placed on an open support about 2 inches above the bottom of the tank; the liquid level is adjusted so that the top of the assembly is immersed to a depth of approximately 2 inches. The connections to the flowmeters are made and the rate of flow of air is initially adjusted at an arbitrary value of about 50 cc. per minute.

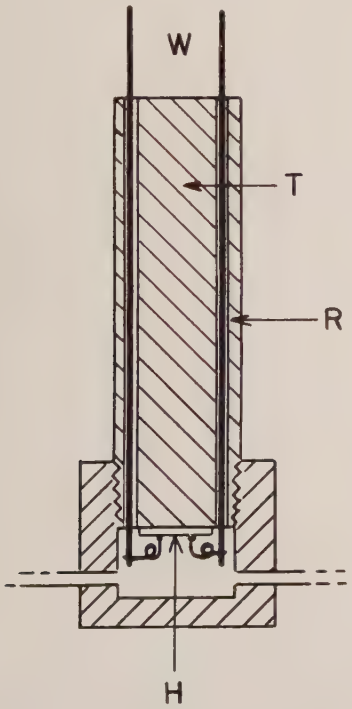

Fig. 4. Diagram of mounting for the electric hygrometer

While the assembly is equilibrating to the temperature of the bath, the four-way valve V is turned to the position for determination of the initial relative humidity. After the test assembly has reached the temperature of the bath and the relative humidity as indicated by the galvanometer readings is constant (this is an indication that the cell has reached the temperature of the bath), the four-way valve is turned to direct the air from above the specimen through the chamber containing the electric hygrometer. Following a time interval of one or two hours, the galvanometer is read to determine the relative humidity of the air leaving the space above the specimen. If the observed relative humidity is beyond a small range (for example, beyond 22 to 25% relative humidity when the air entering the space above the specimen is at about 20%) above the relative humidity of the air entering the specimen chamber, an adjustment of the rate of flow is made. In order to maintain comparable testing conditions, the flow of air is adjusted so that the difference in relative humidities ($r_2 - r_1$) is held within relatively narrow limits. These adjustments are not time consuming nor are the conditions difficult to achieve.

Subsequent to the preliminary adjustments, humidity measurements are made at suitable time intervals until equilibrium conditions have been established and the rate of moisture transfer through the specimen is constant. The selection of appropriate time intervals for the humidity measurements is governed by the permeability of the specimen and the moisture-absorptive capacities of the surfaces and materials exposed to the low relative humidity. It should be emphasized that a constant rate of moisture permeation for various kinds of materials may vary anywhere between a few hours and several weeks or longer.

When the rate of transfer of moisture through the specimen has reached a constant value, the difference in relative humidity between the air entering and leaving the space above the specimen will be constant for a given rate of flow. At equilibrium, the rate of flow and the difference in relative humidity are noted and recorded for the purpose of calculating the permeability on a standardized basis. If the rate of flow Q is given in milliliters per minute and the difference in relative humidity as a decimal (for example, $r_2 - r_1 = 0.230 - 0.200 = 0.030$), then the WVP in grams per square meter per 24 hours as obtained with this equipment is given by the equation,

$$\text{WVP} = 0.042(r_2 - r_1)Q$$

CALIBRATION OF THE ELECTRIC HYGROMETER

The calibration of the electric hygrometer is accomplished with the same equipment that is employed for the permeability measurements. The permeability test cell is assembled as shown in Fig. 2 and the valve V is turned so that the air bypasses the test chamber. In this case, as in the case of the permeability measurements, dry air from the coil K is flushed through the assembly, prior to immersion in the bath. The test assembly is placed in bath B and the rate of flow of air passing over the hygrometer is adjusted at an

arbitrary value ranging anywhere between 50 and 100 ml./min. Bath A is subsequently adjusted at the temperature corresponding to the relative humidity desired for the first point of a calibration curve. After equilibrium has been attained (as indicated by a constant galvanometer reading), the galvanometer reading and the corresponding relative humidity are recorded. The relative humidity is calculated on the basis of the vapor pressures corresponding to the two bath temperatures as described earlier in this paper. In order to obtain three or four calibration points, the temperature of the bath A is merely controlled at the corresponding values.

Typical calibration curves as obtained for an electric hygrometer in the foregoing manner are presented in Fig. 5. These curves are for the same hygrometer and were obtained at two different voltages. The points of interest to which attention is drawn are: (1) that the sensitivity of the hygrometer at a low temperature is exceptionally good, being in the order of 0.0032 R. H. per galvanometer scale division at 2.2 volts and about 0.00025 per galvanometer scale division at 2.8 volts and (2) that, for the small humidity range of interest, the curves are linear; this is a desirable, although not necessary attribute.

A further point of interest regarding the hygrometer is its relatively good stability. During the course of a year, the calibration of an electric hygrometer which had been alternately exposed to widely different temperatures (normal room temperature and 0°F.) changed very little; the order of magnitude of the change was about 0.04 R. H. at a given galvanometer reading. These small gradual changes in the calibration of the hygrometer do not create a serious difficulty insofar as the permeability measurement is concerned. Whenever a change in the calibration occurs, the entire calibration curve through the linear portion is merely displaced, for most practical purposes, parallel to itself. For example, if the initial calibration curve obtained for an electric hygrometer were the one labeled 2.8 volts (Fig. 5), the changes in calibration caused by aging of the element would shift the curve toward the one labeled 2.2 volts. Thus it will be seen that, once a complete calibration curve has been obtained, it is generally sufficient to check a single point and simply construct a new calibration curve through the newly determined point. In constructing this curve, some allowance should be made for the fact that the slope of the curve changes somewhat.

When the differences in the relative humidities are determined in the permeability measurements, a frequent check of the calibration of the hygrometer is easily obtained. Since the relative humidity of the air entering the space above the test specimen is fixed and known by the two bath temperatures, it is merely necessary to note r_1 whenever a check on the calibration is deemed advisable. If any small changes are noted, a new calibration curve is constructed as described above.

RESULTS

The permeability data obtained with the hygrometric sweep gas method on the five samples of moisture-resistant materials included in the TAPPI round robin testing program are presented in Table I. The second column presents the difference in relative humidity of the air entering and leaving the space above the specimen, the third the rate of flow of air over the specimen in milliliters per minute, and the fourth the WVP in grams per square meter per 24 hours. These values, it should be recalled, are for testing conditions in which one side of the specimen was exposed to a relative humidity of 96% and the other to a relative humidity of about 22%; the latter is the mean value for the air entering and leaving the space over the specimen.

In evaluating the permeability of these samples, it was found, as expected, that the time required to establish equilibrium conditions varied from a minimum of about 24 hours for the Pliofilm (sample 4) to a maximum period of about one month for the cellophane-kraft paper laminate (sample 2) with the kraft side

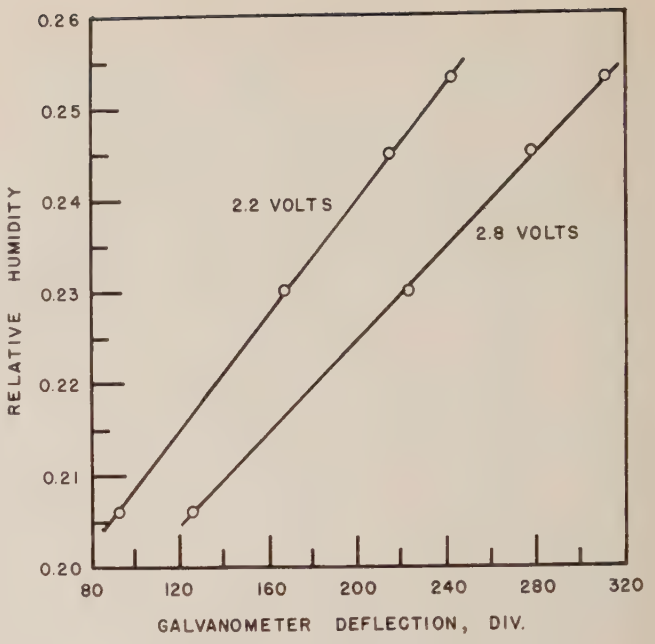

Fig. 5. Calibration curves for small electric hygrometer, 0°F.

Table I. Water-Vapor Permeability Data Obtained with Hygrometric Sweep Gas Method at 0°F.

Sample	*R. H. difference, ($r_2 - r_1$)*	*Rate of air flow, ml./min.*	*WVP g. per sq. m. × 24 hr.*
1	0.026	10	0.011
1	0.037	21	0.033
2	0.020	3.0	0.0025[a]
2	0.013	3.5	0.0019[b]
3	0.035	8.0	0.012
3	0.024	4.6	0.0046
4	0.051	110	0.24
4	0.051	107	0.23
5	0.026	33	0.036
5	0.028	27	0.032
5	0.023	21	0.020

[a] Evaluated with the kraft paper exposed to the low R. H.
[b] Evaluated with the cellophane exposed to the low R. H.

Description of Samples:

Sample 1—300 MSAT-83 Cellophane.
Sample 2—300 Cellophane laminated with 14 lb. of wax to 33 lb. special wet-strength kraft, 65 lb. finished.
Sample 3—Two 25-lb. bleached glassine sheets laminated with approximately 7 lb. of amorphous wax.
Sample 4—140FF. Pliofilm.
Sample 5—24-lb. opaque sulphite sheet laminated with 12 to 15 lb. of wax to 17 lb. supercalendered sulphite sheet with 3 to 4 lb. of wax on one side and 2 to 3 lb. of wax on the other side of the laminated sheet.

Table II. A Comparison of WVP Data Obtained in Different Laboratories

Water Vapor Permeability, g. per sq. m × 24 hr.

Lab.	Method	Sample 1	2	3	4	5
A	Cup	0.019	0.016	0.012	0.20	0.093
		0.020	0.034	0.016	0.26	0.099
		0.045	...	0.011	0.27	0.088
		0.037	...	0.022	0.26	0.085
B	Cup	...	0.10	0.28	...	0.064
C	Sweep gas	0.37	0.20	0.31	0.48	0.48
		0.34	0.16	0.25	0.47	0.42
		0.39	0.16	0.23	0.45	0.39
		...	...	0.17	...	...
D	Sweep gas	0.007[a]	...	...	0.015	...
E	Sweep gas	0.37	0.50	0.28	0.45	0.33
		0.36	0.79	0.67	0.26	0.19
		0.23	0.50	0.96	0.42	0.34
		0.47	...	...	0.40	...
		...	...	...	0.43	...
F	Gas permeability	0.000079	0.0017	0.00014	0.033	0.021
IPC	Hygrometric sweep gas	0.011	0.0025	0.012	0.23	0.036
		0.033	0.0019	0.0046	0.24	0.032
						0.020

[a] Below accuracy of method.

of the sheet exposed to the low relative humidity. When sample 2 was evaluated with the cellophane exposed to the low relative humidity, the time required to establish equilibrium was reduced to about one week. The equilibration times for samples 1, 3, and 5 were about 5, 14, and 3 days, respectively. In each determination, however, the measurements were continued for a period of time considerably longer than that required to establish equilibrium.

The permeability value of 0.0022 g. per sq. m. × 24 hr. obtained for sample 2 is near the lower limit of accurate measurement for the equipment described. If materials having a lower WVP were to be evaluated, it would be necessary to modify the method for controlling the rate of air flow or increase the size of the test specimen. Of the two possibilities, the latter seems more feasible since the test cell could be redesigned to hold a larger specimen, or a number of smaller cells could be employed. Needless to say, a WVP of 0.002 g. per sq. m. × 24 hr. is, indeed, very small.

Since the permeability data obtained by the laboratories participating in the TAPPI round robin testing program are believed to be of interest here for comparison purposes, the results obtained by these laboratories as well as our own are presented in Table II. It is our understanding that a complete report of the round robin tests as sponsored by the Packaging Materials Testing Committee will be published in the near future.

GENERAL DISCUSSION

By utilizing a cryostat and performing the WVP measurements in a bath which is controlled to within a few hundredths of a degree Centigrade, the conditions are such that accurate evaluation is favored. However, should a high degree of accuracy in the permeability measurements tend to be of a lower order of importance, as in a routine test, it may be desirable, insofar as convenience is concerned, to eliminate the bath B and instead perform the permeability measurement in a cold room. The advantages to be obtained in performing the measurements in a cold room conditioned at the desired temperature would be (1) the test assembly would always be in equilibrium with the low temperature, thus eliminating the delay otherwise required for cooling the assembly to the temperature of the bath, (2) it would eliminate the necessity of breaking and making air line connections, (3) it would eliminate the care that must otherwise be exercised to avoid the danger of condensing moisture in the air lines and the chamber of the test assembly, and (4) it would be possible to arrange to have the specimens in equilibrium with the low temperature *before* they are inserted in the test cell; this would also accelerate the test.

In performing the permeability measurements in a cold room, a cryostat for controlling the temperature of bath A would still be required as a means for obtaining the desired low relative humidity. The test assembly which is shown immersed in bath B would merely be exposed to the room. If the temperature control of the room were poor, however, it is strongly recommended that the test assembly be placed in some sort of thermally insulated cabinet. This cabinet would serve as a means for damping out the temperature fluctuations in the room and would thus provide a relatively constant temperature for the assembly. Since the coil L would be exposed to air instead of a liquid, it should be lengthened to retain its heat-exchanging capacity and thereby to ensure that the air entering the test cell is in equilibrium with the temperature of the room or cabinet.

As a further consideration of the flexibility of the method, it will be seen that the space below the specimen could be conditioned in the same manner as that above the specimen. By making the lower chamber a duplication of the upper, it would be possible to control the vapor-pressure gradient across the specimen for a permeability determination at any desired value. Moreover, the facilities of this arrangement would enable one to check the differences in relative humidities both above and below the specimen. This would be of value in ascertaining when equilibrium conditions have been attained and when the rate of transfer of moisture through the specimen is at a constant value. Ideally, the measurement would be continued until the observed increase in the relative humidity above the specimen equalled the observed decrease in the relative humidity below the specimen.

By virtue of establishing a material balance, the uncertainty of knowing when equilibrium has been attained is removed. Although accomplished gravimetrically, this is the principle employed to good advantage in the method described by Cherepow (*2*).

To condition the air flowing through the lower chamber, a third bath would be required if the measurements were performed in a cryostat rather than in a low temperature room. The principle involved in conditioning the air to a given high relative humidity would be the same as that for the lower humidity, as described earlier. As in the case of baths A and B, the third bath could be cooled with the same compressing unit. Cooling of the three baths with a single compressing unit is common in refrigeration practice and would not involve any difficulty.

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Silicate Adhesives for Corrugated Paperboard

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The historical growth of the paperboard and corrugated industries made many demands upon adhesives. The resulting silicate developments are traced and explained. Analyses and properties of the important silicate adhesives are reviewed. Advantages are also indicated for clay and other mixes. Plant control is stressed, covering both operations and quality. Minimum control methods are suggested and "pass the buck" attitudes are censored. A new, cooperative approach to operating problems is urged.

The simplest way to cover development of the various silicate adhesives and the interrelated influence of paperboard is by chronological outline. According to Pliny's Natural History, about 1000 B.C. or so, some Phoenician sailors landed on a far eastern shore, probably the Palestine coast, and prepared their meager meal over a hot fire, built on the sand using a few nearby rocks as supports. Having satisfied their hunger, they stretched out on the sand near the still glowing fire for an undisturbed night's sleep. In the morning, they were amazed to find their fireplace covered by a mass of hard, smooth, glossy material. Today, it is known that the silica sand had reacted with the natural soda rocks under the intense heat of the fire to form an impure silicate glass.

It was many centuries later before sodium silicate was made commercially in this country (*1*). About 1850, a soapmaker in Philadelphia, Thomas Elkinton, read of a soluble waterglass produced in Germany and out of curiosity, he produced some small lots in his plant's furnace. When the Civil War interrupted the supply of rosin used in his yellow laundry soap, he substituted the waterglass solution and found the product had such merit that other soap manufacturers began purchasing this chemical from him. Of course, only one grade of glass was produced from a standard batch of soda and sand, so concentration determination with the hydrometer probably proved a very satisfactory method for controlling quality. Baumé is still a rough measure of solids present and is useful in controlling silicates where the ratio of alkali to sand remains constant.

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During this same period (*2*), single-faced corrugated straw sheets were combined with starch pastes and were used as wrappers for lamp chimneys, bottles, etc. By the early 1900's, the industry was searching for an adhesive which would permit the production of both single-face and double-face corrugated board in a continuous operation. Silicates were available at low cost and provided a strong bond and fast set after introducing only little water into the board. Hence, they became the new corrugated box industry's standard adhesives. Being a new industry, with profitable and limited outlets, costs were not critical and production was not pushed. Hence, the available grades of silicate, both 41 and $42^1/_2$ Bé, were readily accepted even though the board was piled wet, and the bond usually formed in the load.

During this early stage, jute board and straw corrugating medium were standard; the board having a full 72-pound basis weight, dense formation, and high test. The straw board was made from high grade furnish, given a slow, mild cook, which produced well formed sheets weighing at least 32-pounds basis weight. Sixty feet per minute was considered to be a good speed for the corrugated combiner.

As the industry expanded during the 1920's, machine speeds of about 150 f.p.m. were easily attained with an over-all corrugator length of about 50 feet. First efforts were then made to obtain an assured set on the combiner by more accurate control of the silicate and its application. Operators who were technically minded soon realized that if an economical application of silicate flowed into the well-formed sheets rather slowly, ample time was available at the moderate speeds for sufficient heat transfer to form the initial bond before reaching the take-off. These efforts soon led to use of viscosity as the best, single control of adhesive performance, being a direct measure of penetration under flow. The higher the viscosity, the less the pentration, and *vice versa*. Hence, $42^1/_2$ Bé silicate became generally used since it had higher viscosity to retard penetration into the board and provided the reduced spread and lower heat requirement needed for set.

During the 1920's, first attempts were made to use kraft paper as board and much progress was made in overcoming the outstanding problem of pealing. By the early 1930's, business conditions and the initial acceptance of the resulting kraft board caused jute manufacturers to cheapen their product by bulking, etc. Now the dry finished, fourdrinier kraft and the bulked jute were both highly absorbent and permitted excessive penetration despite the high viscosity of $42^1/_2$ Bé silicate. The same conditions forced box manufacturers to seek higher production rates in order to reduce costs and even though equipment was lengthened, the higher speeds reduced the time for set.

As the search for lower costs and more profitable outlets for board increased, specialty products were developed, involving special boards, some of which were hard sized and very difficult to wet and almost impossible to penetrate. By 1935, basis weights of jute liners had been reduced to 64 pounds, kraft was a regular stock, and the entire problem of penetration control was beyond viscosity limitations.

At that time, some box plants tried and adopted mixtures made by mechanically adding enough clay to diluted silicate to restore the viscosity and control penetration (*3*). The diluted silicate gave a liquid phase which provided quick wetting of the most resistant surfaces, and the clay solids concentrated at the glue line until the gel strength resulting from this action prevented further loss of liquid phase. Efficient dispersion of these clays permitted shipment of premixed clay adhesives by tank car and soon resulted in their substantial use. However, some settling did occur under adverse handling or storage conditions, and the wear on improperly chosen pumps and packings was excessive. These problems prevented general acceptance and resulted in further consideration of special silicates.

It has long been known that the ratio of alkalinity to silica in sodium silicate largely determined the rate of set. The lower the alkalinity, the higher the ratio and the faster the set. Unfortunately, the higher ratio glasses are much more difficult to dissolve, and the solutions so produced thicken so rapidly at reduced temperatures as to cause storage and handling problems which precluded their use for many years. However, by 1938, more efficient production methods in both the silicate manufacturing plant and the corrugating plant permitted preparation and use of silicates with a ratio as high as 1:3.40. In addition to lower spreads and faster set, these higher ratio silicates were less tacky and drained cleaner from the metal fingers on the corrugating rolls, thus permitting their use at viscosities higher than previously thought possible.

More and more fourdrinier kraft was being used; lighter and lighter weight jutes were produced declining progressively to the current 52-pound basis weight. Corrugating mediums were made from a variety of materials, including chestnut, kraft, and various mixed paper stocks covering a wide range of absorbing characteristics. Corrugator lengths have been increased to well over 200 feet to provide adequate drying and curing time at speeds up to 450 to 500 f.p.m. The final goal is not yet obtained.

SILICATE MIXTURES

The silicate manufacturer needed more positive and better means of controlling penetration and set. Mixes were again prepared containing still higher clay contents and when used with proper handling facilities, they give very satisfactory results used either cold or heated. The clay must be carefully chosen and efficiently dispersed. The absorption of silicate into the board then concentrates the clay remaining at the glue line resulting in rapid increase in bond strength and very promptly prevents further or excessive penetration. Actually, the higher solids content and reduced penetration of such adhesives greatly reduces the heat requirement for set so that the bond is formed very rapidly and both heating and curing needs are reduced. Such mixes provide both the penetration control and rapid set needed to combine today's wide varieties of board. They give a drier, firmer, flatter, and better stuck board ready for slitting, scoring, and automatic handling at highest speeds. Actually, such mixes have two phases, both subject to changes that can be reflected to advantage in the final adhesive mix. The clay is the solid phase and might be varied from an inert, fire clay type to the highly plastic Bentonite class, each providing corresponding changes in the properties of the mix. The silicate is the liquid phase which can be varied by using different ratios of glass at varying concentrations or by the addition of other chemicals. For example, Monsanto Chemical Company's "Mersize" resin is being added and shows real benefits in reducing the bond between silicate deposits and hot metal surfaces. Other additives are being studied with the hope of obtaining further improvements.

In summary, the following approximate analyses permit useful, theoretical comparison of several adhesive grades of silicate.

Adhesive	*Baumé*	*Viscosity, sec.*	*Ratio*	*Na_2O Alkalinity,%*	*SiO_2%*	*Water loss for set* (4)
A	42.2	112	1:3.22	9.3	29.5	14.7
B	41.0	52	1:3.22	8.9	28.7	15.0
C	39.7	95	1:3.40	8.3	28.2	13.5

To reiterate, Baumé is the standard field method of checking silicate quality providing an easy but rough measure of total solids present. It does not directly measure any adhesive property and is only useful in comparing adhesive grades where the ratio remains constant.

Viscosity is the best, single test of adhesive performance, being a direct measure of penetration under flow. The higher the viscosity, the less the penetration, and *vice versa*. Hence, C (95 sec., 1:3.40 ratio) will not tend to penetrate as readily as B (52 sec., 1:3.22 ratio) and should show some slight reduction in spread, especially on damp or absorbent paper stocks. Similarly, A (112 sec., 1:3.22 ratio) penetrates absorbent stock still less and should provide further spread reductions where needed.

Alkali-silica ratio largely determines the rate of set. The lower the alkali in proportion to silica, the faster the set. Hence, C provides the faster rate of set which also tends to fix the bond without permitting excessive penetration.

Water loss required for initial set (*4*) is the best

measure of operating performance. It provides an index of the time required before handling is possible at the cut-off, thus indicating the operating speeds possible. For example, if the double facer glue station applied 10 pounds of B, then 1.5 pounds of water must be lost from the glue line to provide a bond that will hang together and permit slitting, scoring, and handling at the take-off, approximately 100 feet away. With given heat transfer and paper conditions, this might permit operating at a speed of 300 f.p.m. With grade C a 10-pound spread will only require the loss of 1.35 pounds of water, permitting the formation of an equally good bond at a speed slightly over 330 f.p.m.

Actually, adhesive silicates are prepared to manufacturer's specifications, and within limits they can be made to any desired ratio or viscosity by empirically varying the batch furnish and dissolving operation, providing reasonable solubilities are maintained. Hence, these grades are only representative and do not preclude preparation and use of other grades to meet industry's demands.

PLANT CONTROL

With such a variety of adhesives, the boxmaker needs to work closely with the silicate manufacturer so that he may become sufficiently familiar with the operating conditions to suggest the grade and practice most likely to produce efficient results. However, the day-to-day supervision of the corrugating operation is a plant personnel problem involving both operator training and quality control. This paper does not presume to advise specifically regrading operator training. However, it must be admitted that the low operator productivity of the past few years may not be entirely labor's fault. Management has failed to properly train their workmen because of the pressure of business. Now, a real plant program for operator training is needed and will pay big dividends. Labor costs are by far the largest controllable charge in manufacturing corrugated board. It is a subject well worth top management's attention, and is a likely meeting topic for future consideration.

Quality control in the box shop is very important and has developed along with the growth of the fabricator's appreciation and customer's demands. Good adhesive practice, efficient corrugating operation, and quality maintenance are practically synonymous. They result in greater plant efficiency and more consistent attainment of inherent material expectancies. Of course, commercial laboratories can check both the uncombined materials and the finished products to accurately evaluate the degree of perfection attained, but the time required for conditioning samples for such tests largely precludes their immediate usefulness for plant control.

Meantime, do not discount the oldtimer's ability to tear samples and to discover faulty operating procedures. This practice should be encouraged by supervisors and foremen. Checks made hourly by someone in authority would not be performed too often and they will uncover needless waste and will also provide the experienced background needed for real trouble shooting when necessary. All can visually recognize finger gaps, spotty glue lines, split edges, blisters, unstuck board, etc., simply by examining the glue pattern, and permitting such conditions to continue for any real time is both uneconomical and unforgivable. These visual observations should be confirmed by some physical tests. The bursting strength test, flat crush test, etc., are certainly in order and indicate fabricating efficiency even though the results are not accurate except after time-consuming sample conditioning. However, periodic caliper readings are even more valuable and provide an immediate warning of faulty operation. They call attention to any practice which consistently reduces caliper, such as poor formation, crushing, etc., and thus identify causes which frequently prevent attainment of the strength inherent in the paperboard. Hourly checks on caliper will limit the time necessary to uncover such faults although correcting them may be a difficult, long term program.

Physical check of roll clearances each shift is another easy means of insuring at least reasonable economy and uniformity of silicate application.

Warp is another important consideration and yet it is conspicuously obvious before it causes trouble. Warp not only slows production but it lowers quality due to damage from extra handling, forcing into feeding hoppers, etc. Warp control (*5*) is mainly a question of attaining uniform moisture distribution. The mills exercise reasonable control over their board output but cannot be infallible. All boxmakers should have some facilities for conditioning the paperboard and bringing the combined product into a reasonable moisture balance. Such efforts pay big dividends in easier handling at the take-off which permits higher production on the corrugator, and better handling and production throughout the entire finishing department, all directly reducing costs.

The boxmaker's attitude toward these problems seems fundamentally wrong. Faults too often are hidden by use of an extra pound or two of silicate adhesive. The real cause of the trouble should be run down and corrected. Covering up the trouble wastes material, produces a poorer product, and eventually leads to more inefficient practices. For example, the right answer to highs and lows is not a heavy glue application and extra weights on the belts to crush "down" the high flutes and give over-all contact. The correct answer is to study operating practices, including check of the roll stock tensions, steaming and conditioning, adhesive application, travel across the bridge, passage over guide rolls, etc. Caliper readings and visual observation show where the trouble starts, then the operation can be perfected to eliminate the trouble and obtain a uniform formation.

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Received Feb. 16, 1949. Presented at the Annual Meeting of the Technical Association of the Pulp & Paper Industry. Hotel Commodore, New York, N. Y., Feb. 21–24, 1949.

ASSOCIATION NEWS AND EVENTS

Fourth Engineering Conference

Considerable progress is being made in the preparations for the Fourth Engineering Conference of the Pulp and Paper Industry to be held at the Statler Hotel, Boston, Mass., on October 31 to November 3, 1949.

The growing interest in this very important meeting is being reflected in the problem of accommodating all of the Association committees that wish to sponsor programs. Since the previous conferences have been attended by the leading chief engineers of the pulp and paper industry of the United States and Canada every effort has been made to enable everyone to be present at every session. It may become necessary after this year to hold more than one session at a time.

Since last fall two new committees have been established in the Engineering Division of the Technical Association; one on Electrical Engineering and the other on Engineering Data Sheets. It is quite likely that in another year a Chemical Engineering Committee may be organized to deal with unit operations such as evaporation, liquor recovery, etc. There is also a strong urge being made by mill superintendents to hold a Papermaking Conference at the same place as the Engineering Conference. At the Boston meeting this effort will be initiated by means of a relatively small (about 75) round-table meeting to deal with papermaking problems of an engineering nature.

Preliminary plans are under way to hold the 1950 Engineering Conference at Cincinnati. Although it would be desirable to have a relatively small attendance at these Engineering Conferences the interest has been greater than anticipated. Consequently, as the meeting attendance grows larger it will become necessary to subdivide the program so that the attendance at any one session will not be so large as to discourage the fine discussions such as those that have prevailed at the earlier conferences.

On March 30 a meeting of the sponsoring company representatives was held at the Hotel Statler in Boston to discuss plans for the general program and plant visits. The enthusiasm at this meeting gave assurance of the way in which visiting engineers will be cared for at the Conference. A. E. Bachmann, President of TAPPI, R. G. Macdonald, Secretary, and J. W. Hemphill, Secretary of the Engineering Division were present and discussed the history of the previous conferences and plans for the 1949 meeting.

Those present included F. K. Becker and H. G. Ingraham, Bird Machine Co., Ralph Briggs, Draper Brothers, C. J. Gendron, Fitchburg Paper Co., C. E. Sullivan and H. O. Ehrisman, Foxboro Co., D. H. Putnam and A. A. Stone, General Electric Co., S. F. Marr, Hollingsworth & Vose Co., R. Nivision, Improved Paper Machine Co., Jerry Blakely, Johns-Manville Co., W. C. Lodding and Chas. S. Conington, Lodding Engineering Co., C. S. Hardy and Frank Dustan, Magnus Metals Co., Milton Jacobs and E. T. Jones of Chas. T. Main, Inc., E. B. Knowlton, Norton Co., C. S. Barton, Charles Adams, and R. Donald Rusden, Rice Barton Corp., Roy Tewksbury, Stowe-Woodward, Morris LaBelle, Tileston & Hollingsworth Co., and S. T. Orton, Union Machine Co.

This group elected Milton Jacobs of Chas. T. Main, Inc., as Chairman of the Arrangements Committee. This committee met in Boston on April 29 and appointed the following subcommittees: Banquet—Ralph E. Briggs and Charles S. Barton, Reception—Roy Tewksbury and Robert Nivision, Mill and Plant Visits—A. L. Lincoln, Jr., and Robert Nivision, Finance—Harold G. Ingraham and Edmard T. Jones.

Summer Meetings

The Technical Section of the Canadian Pulp and Paper Association will meet at the General Brock Hotel, Niagara Falls, Ont., on June 1–3, 1949. In addition to the regular technical sessions there will be a number of mill visits.

The TAPPI Empire State Section annual meeting will be held at the Sagamore Hotel, Bolton Landing, Lake George, N. Y., on June 2–4, 1949. Foster P. Doane of the Sandy Hill Iron and Brass Works is chairman of the arrangement committee.

The Maine-New Hampshire Section will meet at the Wentworth-by-the-Sea on June 17–18, 1949, on Newcastle Island, Portsmouth, N. H.

Division and Committee Chairmanship Changes

President Bachmann has made the following Division chairmanship appointments:

Engineering: George H. Pringle, Mead Corp., Chillicothe, Ohio, to succeed J. W. Hemphill of Johns-Manville Sales Corp., New York, N. Y.

Testing: James d'A. Clark, Longview, Wash.

Industrial: Werner Kaufmann, Kupfer Bros. Paper Co., Chicago, Ill., to succeed F. C. Goodwill.

Pulp Manufacture: F. C. Goodwill, St. Regis Paper Co., Kalamazoo, Mich., to succeed H. W. Bialkowsky.

Paper Manufacture: A. L. Sherwood, Sutherland Paper Co., Kalamazoo, Mich.

Converting and Consuming: R. A. Wilkins, Bird & Son, E. Walpole, Mass.

Research Development: H. W. Bialkowsky, Pulp Div., Weyerhaeuser Timber Co., Longview, Wash., to succeed G. J. Brabender of the Marathon Corp., Rothschild, Wis.

A. Kenneth Warner, Skinner & Sherman, 246 Stuart Street, Boston, Mass., has been appointed Chairman of the Paper Testing Committee to succeed B. W. Scribner of the National Bureau of Standards who was chairman for more than twenty years.

Wm. McIntosh, Jr., Southern Corp., Savannah, Ga., has been appointed Chairman of the Mill Maintenance and Materials Committee to succeed George H. Pringle.

Robert F. DeLong, Marathon Corp., Menasha, Wis., has been appointed Chairman of the Microbiological Control Methods Committee to succeed J. W. Appling of the Buckman Laboratories, Memphis, Tenn.

A. M. Heald of the Marathon Corp.; Menasha, Wis., has been appointed Chairman of the new sub-committee on Waxes and Microcrystalline Waxes of the Nonfibrous Materials Testing Committee.

Charles A. Sibler, Chief Engineer, West Virginia Pulp and Paper Co., New York, N. Y., has been appointed Chairman of the Steam and Power Committee to succeed J. E. A. Warner of the Robert Gair Co., New York, N. Y.

Albert S. Goodrich, Chief Engineer, Hammermill Paper Co., Erie, Pa., has been appointed Chairman of the newly organized Electrical Engineering Committee.

Noel Phillips, Hollingsworth & Whitney Co., Waterville, Me., has been appointed Chairman of the Papermaking (Fourdrinier) Committee to succeed Burt L. Kassing, Ecusta Paper Co., Pisgah Forest, N. C.

LOCAL SECTION ACTIVITIES

Reports of Meetings, Personnel and Events

Pacific

The Pacific Section held its annual meeting on April 8, 1949 at Longview, Wash. Officers elected for the year 1949–50 are: *Chairman*—W. F. Holzer, Central Research and Technical Dept., Crown Zellerbach Corp., Camas, Wash.; *Vice-Chairman*—R. I. Thieme, Soundview Pulp Co., Everett, Wash.; *Secretary-Treasurer*—R. M. True, General Dyestuff Corp., Portland, Ore.; *Executive Committee Members*—B. E. Natwick, Appleton Wire Works, Camas, Wash., Otto H. Sangder, Rayonier Inc., Hoquiam, Wash., and E. O. Ericsson, Puget Sound Pulp & Timber Co., Bellingham, Wash. Harold C. Wall, Longview Fibre Co., Longview, Wash., retiring Chairman, and H. W. Bialkowsky, Weyerhaeuser Timber Co., Pulp Division, Longview, Wash., member of the National Executive Committee are members of the Executive Committee of Pacific Section ex officio.

The afternoon Technical Program of the April 8 meeting was given over to the Shibley Award Contest, an annual competition sponsored by the Pacific Section. This year the Shibley Award Committee was headed by Howard C. Graham, Central Research & Technical Dept., Crown Zellerbach Corp., Camas, Wash. Mr. Graham's committee had arranged for the presentation of all of the Shibley Award papers at the Longview Meeting, believing that this arrangement, by putting all participants on an equal audience basis would stimulate more interest in the contest. The wisdom of this decision was evidenced by the record attendance at Longview of over two hundred members and guests.

The April 8 meeting was also significant in that, for the second year, the Pacific Section had as its guests fifty technical students from the universities and colleges of the Pacific Northwest. This group of men was given an idea, through visits to the Weyerhaeuser and Longview Fibre plants and attendance at the TAPPI Meeting, of the opportunities awaiting the young technical graduate for a career in the pulp and paper industry.

Vance L. Reynolds of the Puget Sound Pulp & Timber Company, Bellingham, Wash. took the honors of the year in the Shibley Award Contest. Mr. Reynold's prize-winning paper, "Separation of Dirt from Unbleached Pulp by Centrifugal Type Classifiers," was delivered at the afternoon technical meeting.

The Shibley Award Contest involves a fifty dollar cash prize each year for the best paper presented by a young technical man actively engaged in some phase of the pulp and paper industry. The contest, unique with the Pacific Section, was named for the late "Cap" Shibley, a Pacific Coast engineer active in TAPPI and one who was determined to encourage young men. All contestants, and there were four this year, receive an autographed copy of Sutermeister's "Chemistry of Pulp and Paper."

The contest is dedicated to "promotion of good workmanship at a professional level." It achieves its purpose by focusing attention on young technical men and engineers in the industry who are not normally heard from, and by focusing attention on everyday or mill operation types of problems.

Reynolds personifies the type described. He is 25 years old and a native of Bellingham, Wash. He attended Washington State College for one year and was transferred to the University of Kansas under the Navy V-12 program. After graduating with a degree of Bachelor of Science in Chemical Engineering in 1945, he had six months' additional training in the Midshipman's School at Notre Dame University. From there he was commissioned as an Ensign. Vance Reynolds has been with Puget Sound Pulp & Timber Company for two and one-half years doing investigational work of the type described in his paper.

The other contestants were Everett J. Reichman, Woodfibre Division, Simpson Logging Co., Shelton, Wash., who talked on "Evaluating Pulp for Soft Board Manufacture"; Robert S. Towne, Fibreboard Products Inc., Port Angeles, Wash., who discussed "Attaining Optimum Boiler Operation"; and J. A. Dykstra, Publishers' Paper Co., Oregon City, Ore., who presented a paper on "Furnish Measurement Problems of a Fast Newsprint Machine."

Harold C. Wall of Longview Fibre Company was chairman of the meeting and Howard C. Graham of Crown Zellerbach Corp. was moderator of the Shibley Award panel. Reynolds paper will be published in a later issue of *Tappi*.

Following the afternoon technical session, members and guests attended a reception arranged by the host mills honoring a distinguished visitor, Dr. Erik Hagglund of the Swedish Forest Products Research Laboratory, Stockholm, and his associate Dr. Hans W. Giertz.

Dr. Hagglund presented a paper at the dinner meeting on the subject "Chemistry of the Sulphate Process" which was of special interest because of the time he has devoted to this field during recent years.

The Executive Committee of the Pacific Section held a luncheon meeting on April 8 to discuss plans for the technical program of the TAPPI Fall Meeting to be held in Portland, Oregon, September 11–15, 1949. Details of the program will be released at a later date.

HOWARD C. GRAHAM AND ROBERT M. TRUE

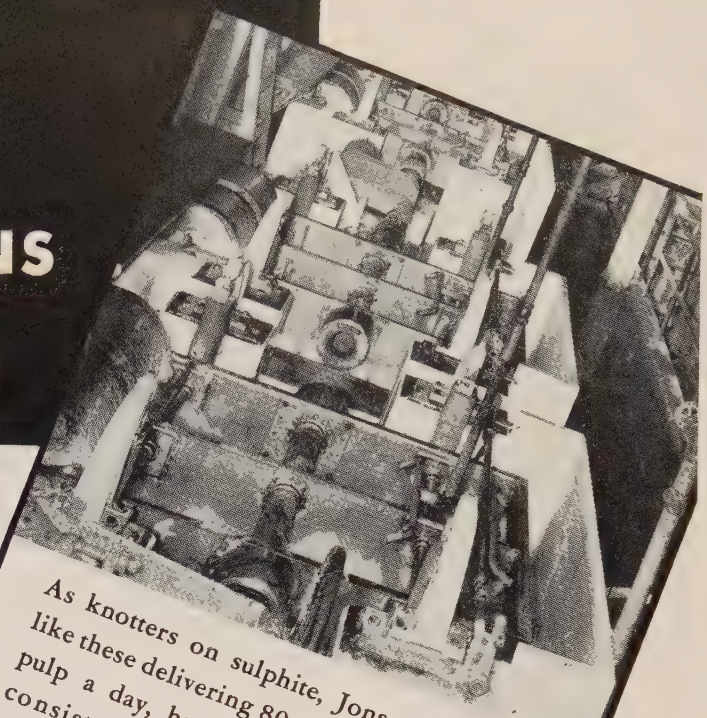
Delaware Valley

Each year the Delaware Valley Section invites an outstanding authority to speak on a subject of theoretical or highly technical nature so that the Section may keep abreast of the new trends in the industry. This year Prof. Herman Mark of the Polytechnic Institute of Brooklyn was invited to speak at the March 24th meeting of the Section to discuss the most recent progress in cellulose research. Nearly 70 members of the Section attended the dinner before the regular meeting held at the Engineers Club in Philadelphia, and this group was augmented by many additional members arriving in time for the discussion which was preceeded by a short business session. John Macadam, Chairman of the Nominating Committee consisting of himself, J. Paciello and K. W. Britt of the Scott Paper Co. announced the following nominations of officers to be elected for the coming year: *Chairman*—John Weidner, Container Corporation of America, Manayunk, Pa.; *Vice Chairman in Charge of Programs*—August Erspamer, P. H. Glatfelter Co., Spring Grove, Pa.; *Vice Chairman in Charge of Membership*—James Eberl, Scott Paper Co., Chester, Pa.; *Secretary-Treasurer*—L. V. Hans, Hercules Powder Co., Wilmington, Del.; *Executive Committee*—W. Allan Schenck, Riegel Paper Corp., Milford, N. J.

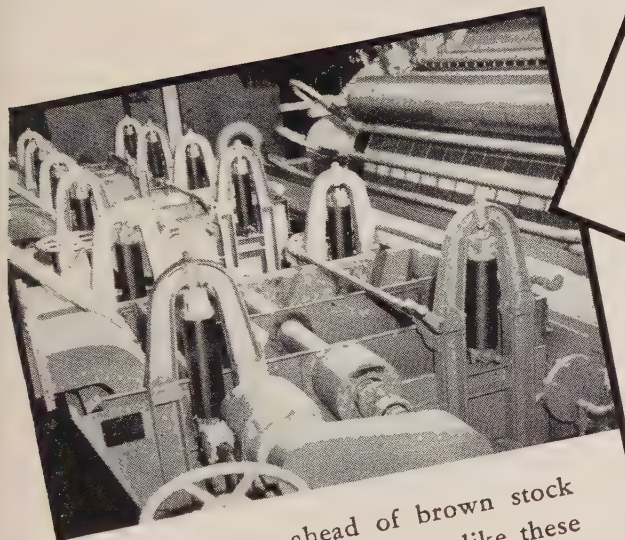
Dr. Erspamer, Chairman of the Program Committee introduced Dr. Mark who was able to keep the interest of

(*Continued on page 40 A*)

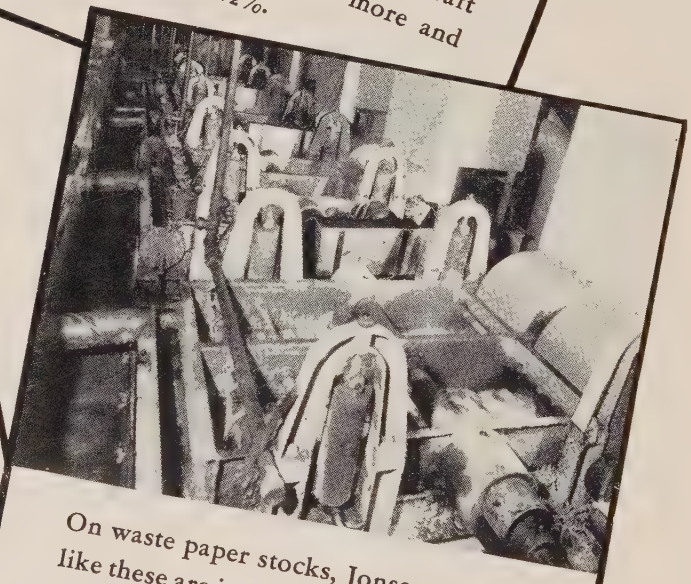
Here's What BIRD JONSSON SCREENS Can Do For You



As knotters on sulphite, Jonsson Screens like these delivering 80 to 100 tons of clean pulp a day, handling stock up to 1½% consistency; on groundwood and kraft they're delivering 150 tons or more and handling stock up to 2½%.



As knotters ahead of brown stock washers, Jonsson Screens like these are increasing washing efficiency and economy and assuring vacuum maintenance and maximum recovery of black liquor. Foaming is no longer a problem.



On waste paper stocks, Jonsson Screens like these are just the ticket for removing wet strength paper, cellophane, string, paper clips, rubber bands or what have you. Tailings loss is negligible. Capacity is great.

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Dicalite improves formation—not by chemical means because it is inert—but by physical action of causing a more thorough and uniform dispersion of fibers at the wet end during formation. This action is peculiar to diatomaceous earth, due to the structure of the particles. We will be glad to mail you full information or send a representative on request.

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the group during the entire evening's discussion which lasted nearly two hours and was finally disbanded to meet train schedules.

Prof. Mark Discusses Cellulose

The speaker very briefly outlined present accepted theories relative to the structure of the cellulose molecule and its approximate weight before reporting on the current work being done on investigating more accurate methods for determining the average molecule weights of cellulose and also on the probable morphological structure of cellulose fibers. The regions under discussion had dimensions of the order of 10, 100, and 1000 Angstrom units.

The study of improved techniques and methods of obtaining more accurate measurements of molecular weight of cellulose molecules is being carried on in several laboratories. The results of earlier investigations had indicated that a linear relationship existed between intrinsic viscosity and molecular weight, but the results of more recent improved techniques used in measuring molecular weights obtained on solutions of cellulose in cuprammonium and cupriethylenediamine indicates that this linear relationship exists only up to molecular weight of approximately 150,000, above which, the intrinsic viscosity increases more and more slowly with increased molecular weights. When the data from these investigations now in progress have been published, it will be possible to evaluate these relationships more accurately.

The use of a modified ultracentrifuge cell of very thin dimensions is one of the new techniques which makes possible measurements on direct solutions of cellulose. The width of the concentration-gradient in the ultracentrifuge cell is a measure of the molecular weight distribution. This technique has shown some promise of being applicable in the study of the fibers during various steps of the pulping process.

Another new method being investigated at the Institute of Polymer Research employs an inert glass diaphragm with pore sizes of the order of 30 Angstrom units. The average molecular weight is determined by osmotic measurements.

Although there is general agreement between investigators that certain places in the cellulose-molecule chain have a much greater tendency to split than at others, there is disagreement as to the differences in the structural units at these points.

The X-Ray, the heavy water, and the density methods of measuring the crystallinity of cellulose do not destroy the cellulose and give higher values of the amorphous portion than the destructive hydrolysis method of Nicholson. Reference was also made to the paper by Dr. B. M. Siegel in the March 1949 issue of *Tappi*.

Specific questions on application of techniques and theories were brought out in the discussion following Dr. Mark's paper.

Dr. Erspamer announced that the response from the questionnaire on testing methods had been very gratifying and that the April panel meeting under the guidance of R. J. Knoll of Scott Paper Company should prove of considerable interest. (Note: This meeting was held at the Engineers Club, Philadelphia, Pa. on April 28, 1949 and will be reported in the June issue of *Tappi*.)

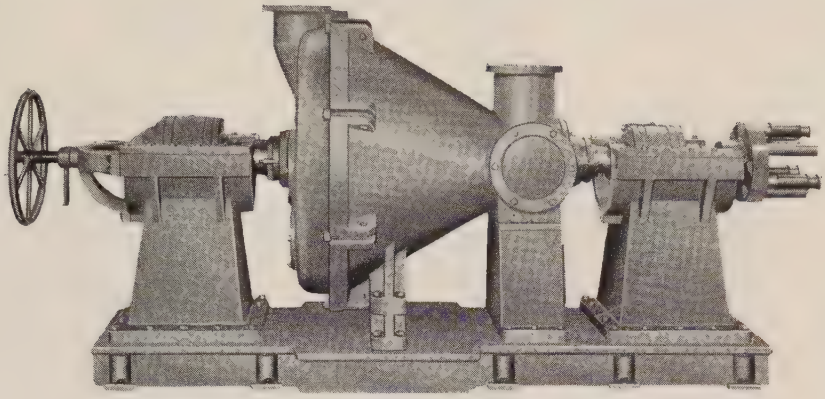
J. P. Weidner, *Chairman*
Miss L. V. Hans, *Secretary*

Chicago

A panel discussion on coating and laminating adhesives was held at the meeting of the Chicago Section, at the Chicago Bar Association, March 21, 1949. The panel consisted of three members, E. B. Osborne, Technical Serv-

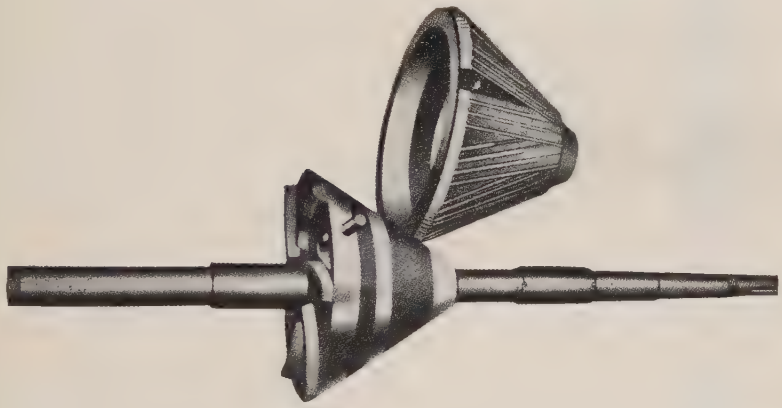
(*Continued on page 42 A*)

THE HERMANN IMPROVED
CLAFLIN
CONTINUOUS BEATER & REFINER

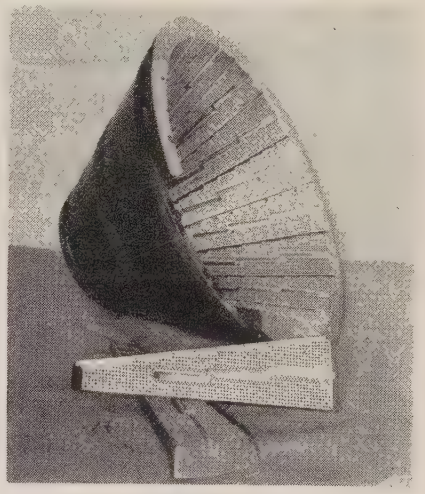


IN FOUR SIZES

Number 0 for experimental and test purposes. Numbers 1, 2 and 3 for production.



Auxiliary Plug mounted securely on shaft ready to receive Quick Change Plug Liners: Cast Steel and Alloy Iron with $\frac{3}{8}''$ and $\frac{1}{2}''$ wide bars. Regular Liners with $\frac{3}{16}''$, $\frac{1}{4}''$, $\frac{3}{8}''$ $\frac{1}{2}''$ and $\frac{3}{4}''$ wide bars.



Hermann Sectional type shell filling for maximum brushing and hydration. Also, one-piece cast steel shell liners with $\frac{3}{8}''$ and $\frac{1}{2}''$ wide bars.

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Groundwood screenings
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Steamed wood at elevated pressures
Semi-Chemical pulp
Waste paper
Straw pulp
Asplund fiber
Untreated (green) wood chips
Bagasse

No distortions due to mechanical strains or temperature changes develop in the new Bauer.

End products now being produced from a wide range of materials after defiberization in Bauer disk pulpers.

PRODUCTS HEREWITH — MATERIALS USED ON THE LEFT

- CONTAINER BOARD
- BOXBOARD
- WALL BOARD
- TISSUES
- TOWELING
- NEWSPRINT
- ROOFING FELT
- LINOLEUM FELT
- SPECIALTIES

FUNCTIONS:

- To disperse pitch and wood dirt
- On de-inking of old papers

So thorough, fast and economical is the action that more and more mills are installing Bauer's.

INVESTIGATE. PERHAPS YOU ALSO SHOULD BE USING BAUER PULPERS.

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ice Engineer, B. F. Goodrich Chemical Co., who spoke on "Application and Use of Geon Lattices in the Paper Industry," C. E. Fawkes, Secretary and Sales Manager, Pyroxylin Products Inc., who spoke on "Coatings and Hot Melts," and J. C. Dean, Manager of the Chemical Products Division, Socony Vacuum Oil Company, who had for his subject "Petroleum Laminates and Coatings for the Paper Industry."

Mr. Osborne in describing the Geon lattices said that they are water dispersions of polyvinyl chloride with a particle size averaging 0.2 microns and carry a negative charge. Most of them require that an ester plasticizer be added in the form of an aqueous emulsion although one resin, which does not require a plasticizer, provides relatively good moisture-vapor protection. The resins, which can be applied by knife, roll, brush, and air knife coaters, have a wide variety of applications including the packaging of meat, lining fiber drums, and coating washable wallpaper.

Mr. Fawkes stated that hot melts are film forming materials as distinguished from waxes or resins and they must not poylmerize or oxidize when heated to high temperatures. They are made from resins, plasticizers, waxes, oils, and pigments. Viscosity, softening point, flexibility, gloss, film strength, specific adhesiveness, and maintainence of adhesiveness on chilling are all properties, which can be controlled in hot melts. They are applied as peelable coatings in the protection of machine tools and cheese and also to paper and foils. In the application of hot melts to thin materials like paper or foil the material to be coated has to be in the form of a web under tension; the web often being preheated before the application of the hot melt and chilled afterwards. Two applications of printing, using hot melts were pointed out by Mr. Fawkes, one being the printing on stockings with a hot melt containing a white pigment and another being the Brooklyn newspaper, which has been printed with a hot melt.

Dr. Dean reported that as a laminating material, microcrystalline waxes must serve as a binder to hold two pieces of paper together and also serve the supplementary function of providing a moisture-vaporproof barrier. These waxes must have sufficient adhesiveness under a wide variety of conditions, sufficient cohesiveness not to rupture within itself and must function over the temperature range 0–110°F. Dr. Dean stated that in addition to the above requirements, these waxes must be easy to apply and be available at low cost. These amorphous waxes are produced from petrolatum by removing the oil. They have a crystal size about 1/40th that of paraffin.

The April meeting was held on April 18th and featured the subject of tube winding. J. J. Callahan, manager of the Cleveland Container Co., Plymouth, Wis., discussed spiral-wound containers and Burger Graves, asst. sales manager of the Sefton Fibre Can Co., St. Louis, Mo., discussed cylindrical containers and various closures. Both speakers discussed labels, adhesives, and various treatments for chemical resistance and decorativeness of these containers.

The May 16th meeting was to be devoted to the subject "Adhesives" and will be reported in a later issue of *Tappi*.

ALBERT K. ROACH, *Secretary*

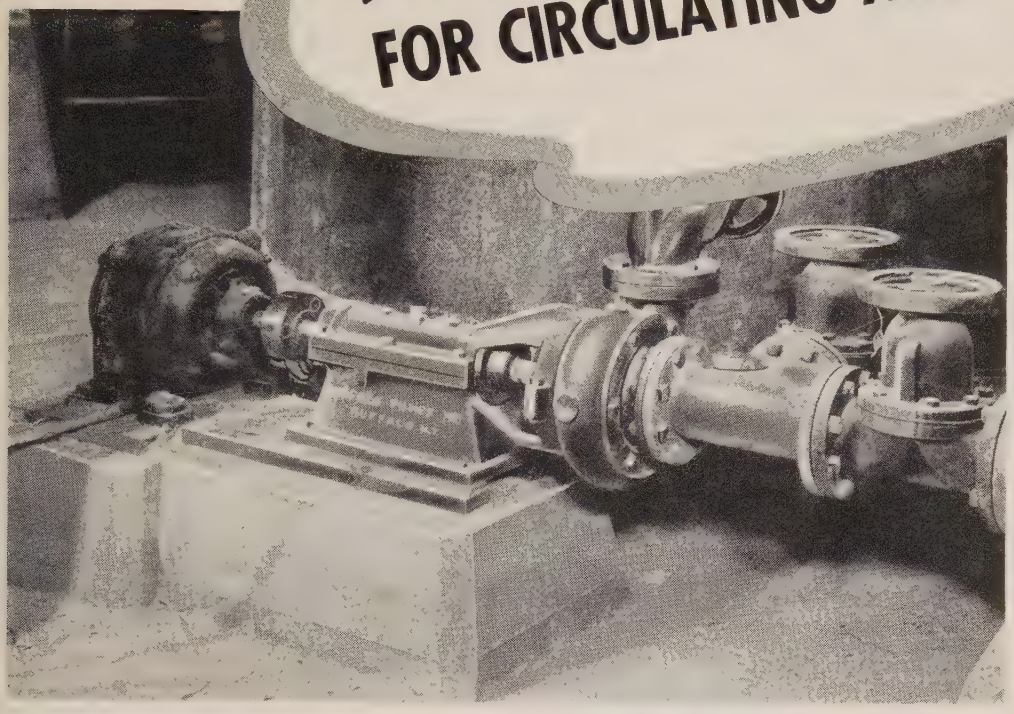
Empire State

C. L. CLARK DISCUSSES VACUUM PUMPS

"The Application of Vacuum Pumps in Industry" was discussed by C. L. Clark of Clark & Vicario Company of New York, as he addressed 70 members and guests of the Hudson River Division of Empire State TAPPI at a dinner meeting in the Village Inn, South Glens Falls, on March 17th. Following a rapid presentation of his broad subject,

(*Continued on page 44 A*)

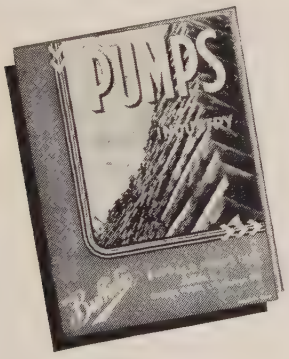
MAXIMUM EFFICIENCY
FOR CIRCULATING AND AGITATING



"Buffalo"

SOLID SHELL

PAPER STOCK PUMPS



What stocks do you handle? For economy and trouble-free service, install the pump BUILT for your job. Pick the RIGHT pump from "Buffalo" Bulletin 953-F, above, which gives all data and ratings. Write for your copy now!

YES! GO WEST!
1949 Fall Meeting TAPPI
Portland, Oregon

NON-CLOGGING SERVICE ON HIGH OR LOW CONSISTENCY STOCK . . .

On-the-job experience—not just theory—has shown that "Buffalo" Solid Shell Single Suction Pumps are particularly suited to circulating and agitating service. This, of course, calls for handling large volumes at relatively low heads, and consistencies that are often pretty high.

From the standpoint of first cost and maintenance, these pumps are real money-savers. Shells are designed to avoid wear on internal walls. Impellers are non-clogging. Slow operating speeds with high volume mean extra years without repair. Removable side plate allows quick rotor inspection without disturbing discharge piping.

For low-cost, *uniform* stock mixing, use the most efficient method—"Buffalo" Solid Shell Pumps! Operators prefer them.

BUFFALO PUMPS INC.

528 BROADWAY BUFFALO, NEW YORK

Canada Pumps Ltd., Kitchener, Ont.

A BETTER CENTRIFUGAL PUMP FOR EVERY LIQUID

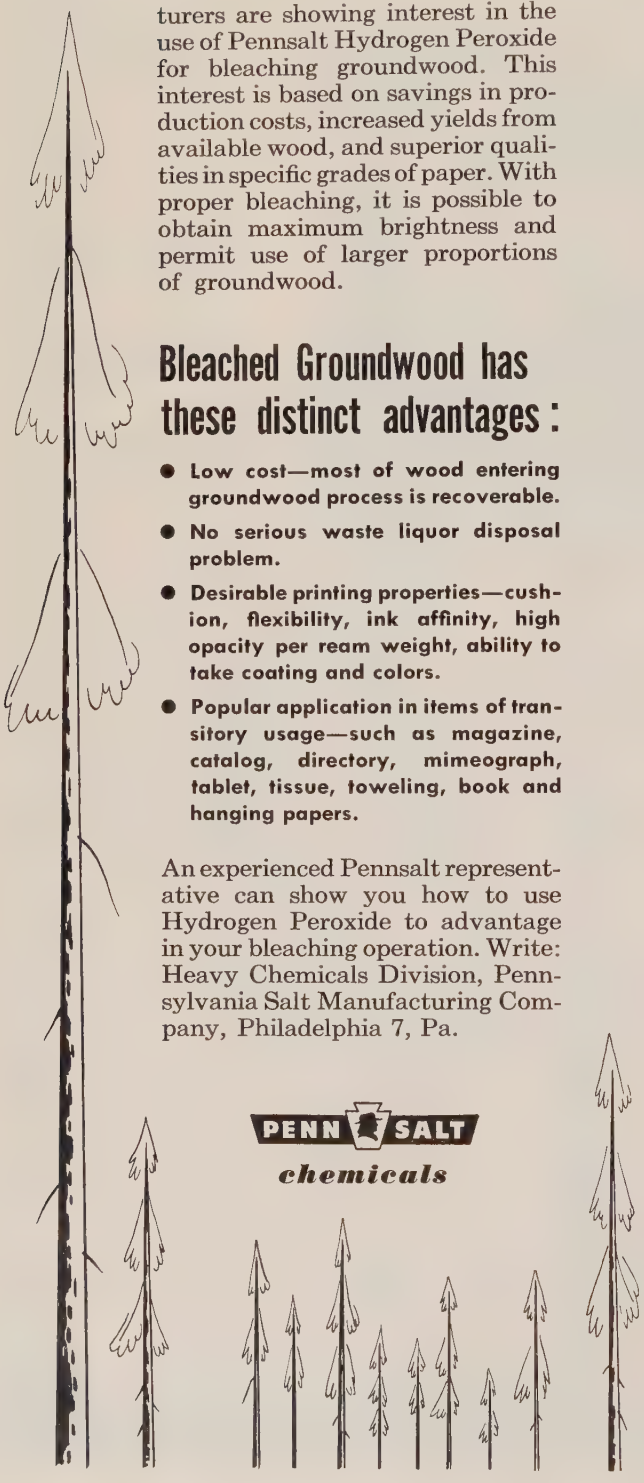
Pennsalt Hydrogen Peroxide for Bleaching Groundwood

More and more paper manufacturers are showing interest in the use of Pennsalt Hydrogen Peroxide for bleaching groundwood. This interest is based on savings in production costs, increased yields from available wood, and superior qualities in specific grades of paper. With proper bleaching, it is possible to obtain maximum brightness and permit use of larger proportions of groundwood.

Bleached Groundwood has these distinct advantages:

- **Low cost—most of wood entering groundwood process is recoverable.**
- **No serious waste liquor disposal problem.**
- **Desirable printing properties—cushion, flexibility, ink affinity, high opacity per ream weight, ability to take coating and colors.**
- **Popular application in items of transitory usage—such as magazine, catalog, directory, mimeograph, tablet, tissue, toweling, book and hanging papers.**

An experienced Pennsalt representative can show you how to use Hydrogen Peroxide to advantage in your bleaching operation. Write: Heavy Chemicals Division, Pennsylvania Salt Manufacturing Company, Philadelphia 7, Pa.



PENN SALT
chemicals

Mr. Clark answered individual questions on the problem of removing water on the paper machine.

With machines running at faster speeds, he said, the quantity of water to be removed is increased not only because of the speed but also because of additional water added to produce the desired formation on the wire. Some high speed paper machines, he explained, now use as much as 30,000 gallons per minute on the Fourdrinier wire. After considerable drainage in the table rolls, the water enters the No. 1 suction box at from one to three per cent consistency, Mr. Clark continued, and leaves the final suction box at approximately 12 per cent consistency.

Thus, the speaker pointed out, in large machines 4000 to 5000 gallons per minute are removed by suction boxes. This volume calls for both wider and deeper suction boxes with larger discharge of pipes rather than the addition of more suction boxes. Failure to use these larger boxes, Mr. Clark warned, results in uneven wet spots in the sheet. It may also produce water in the control valves which disturbs the graduated vacuums on the individual suction boxes.

Mr. Clark said the paper web should leave the suction couch at from 18 to 22 per cent consistency. For speeds below 1000 feet per minute, only enough vacuum is required at the suction presses to remove the small quantity of water squeezed out at the nip of the rolls. For speeds about 1000 feet per minute, it is necessary to maintain as much as 22 inches of vacuum to prevent water from splashing and wetting the sheet.

The speaker explained the action of the felt conditioners in maintaining clean felts. Mention was also made of application of as much as five inches of vacuum on a suction roll in a new cylinder mold forming machine.

New pressurized head boxes require the elimination of entrapped air which may run from one and one-half to five per cent by volume in ordinary newsprint, Mr. Clark continued. When this air is removed the fibers will be much better dispersed in the sheet.

A new rubber belt rotary suction was decribed as being very useful in increasing the speed of wall board being produced on the Fourdrinier wires.

The Future of the Small Mill

The regular April dinner meeting of the Metropolitan Group of the Empire State Section of TAPPI took place at Fraunces Tavern in New York City on April 12, 1949 with John B. Calkin presiding as chairman. The business part of the meeting was short but covered many important points:

1. Election of officers for the year 1949–50 resulted in the reelection of the following: John B. Calkin, *Chairman*, Lewis S Reid, *Vice Chairman*, and Henry Perry, *Secretary*.

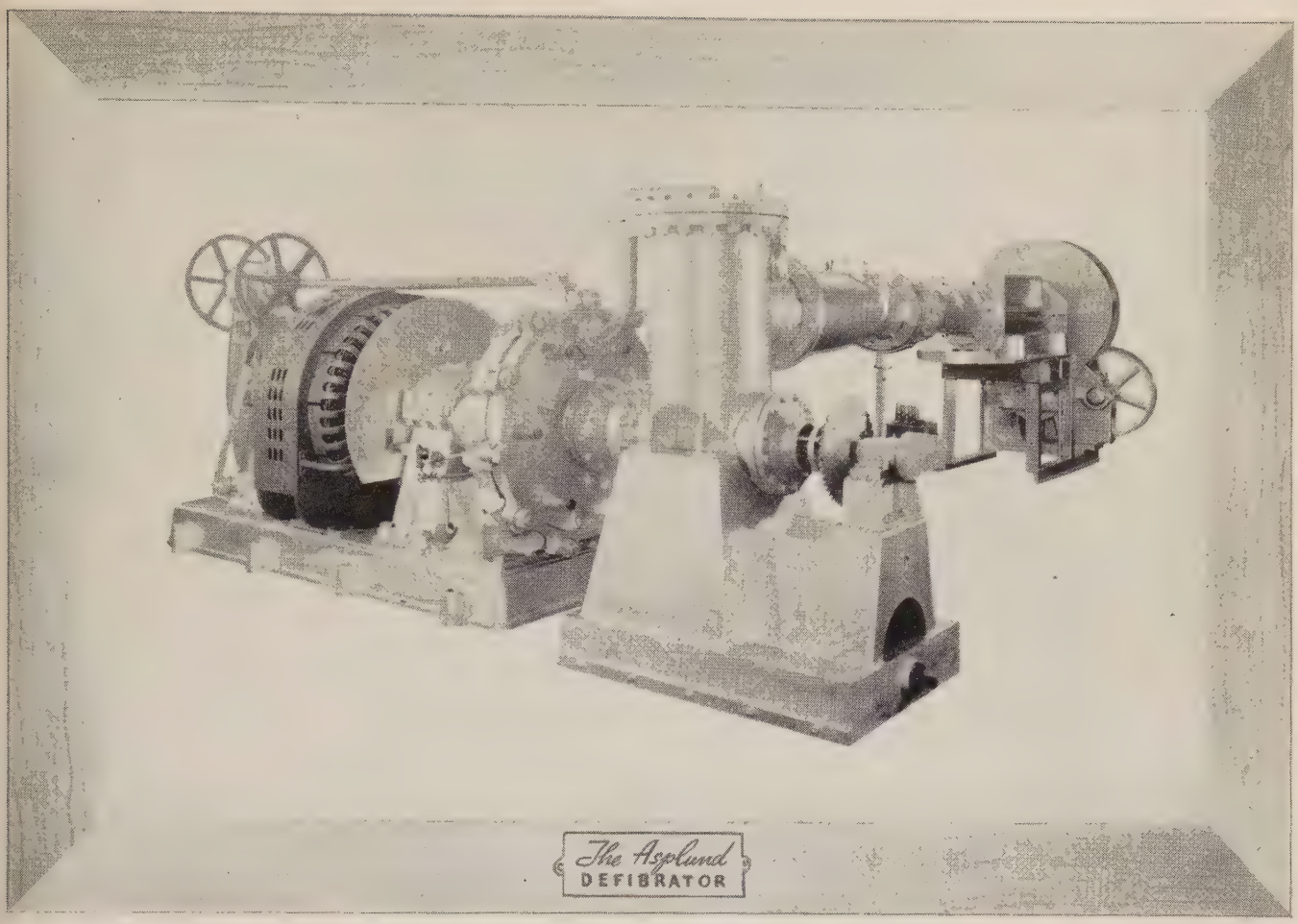
2. Mr. Calkin read the report of Secretary Perry who was out of town. The report showed the Group to have grown into one of the largest groups of its kind in the short period since its inception in 1948.

3. A motion was made and passed to send Jack Butterworth and Socony Vacuum Oil Co. a vote of thanks for the help they rendered in mailing all notices and correspondence to the membership during the past year.

4. Bill Willets, chairman of our Program Committee announced that the final meeting of the year will take place on May 9, the second Monday instead of the usual second Tuesday. A talk and demonstration will be presented by the New York Telephone Co. on "Highways of Communications and Microwaves."

5. Mr. Hemphill of TAPPI announced that the Fall Meeting of TAPPI will be held in Portland, Oregon on September 12–15. At a previous meeting, the Advisory Board had appointed Jack Butterworth of Socony Vacuum and Bill Willets of Titanium Pigment Co. to represent the Metropolitan Group at this meeting.

(*Continued on page 46 A*)



THE 100th *Asplund* DEFIBRATOR

Built in the United States

By D. J. MURRAY MANUFACTURING CO., Wausau, Wisconsin

For AMERICAN DEFIBRATOR, INC., New York, N. Y.

WE ARE PLEASED to announce the completion of the 100th Asplund Defibrator made for us by D. J. Murray Manufacturing Co., well known machine builders for the Pulp and Paper Industry.

The combined output of Asplund Defibrators in the United States and Canada now exceeds 600,000 tons per year.

Growing acceptance of the Defibrator method of producing pulp for hardboard, insulating board and roofing felt—from the wood chips of round logs or sawmill waste, or from practically any other fibrous ligno-cellulose material such as bagasse or straw—proves two points—that Asplund pulp is superior for this purpose, and that the process is *profitable.*

Asplund pulp is homogeneous and free, with individual fibres intact but well separated, and it has good felting properties. The yield is high (90-95% by weight on a b.d. basis) and both power and maintenance costs are extremely low. Facts, figures, and technical advice on defibration are available without obligation.

Sold exclusively in the United States and Canada by

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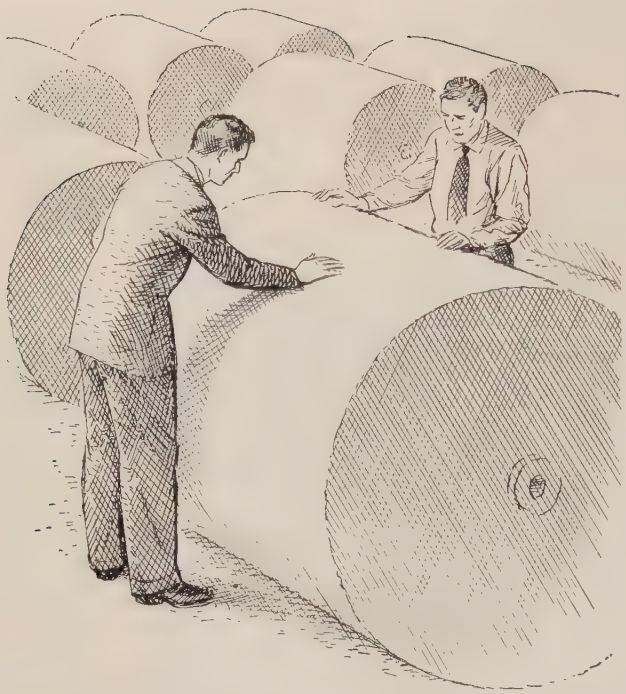
***West Coast:* A. H. Lundberg, Textile Tower, Seattle, Washington**



"One test convinced us!"

"The finish is far better than previous finishes since we've put that Butterworth Roll in the stack. We find that production is more uniform with fewer delays and breakdowns. Our labor costs are lower, too. If one Butterworth Calender Roll can do that, standardizing on Butterworth Rolls would mean a definite economy and better quality finishes on all future work."

Butterworth Calender Rolls are made of the finest materials available, and are locked on the shaft under tremendous pressure. They can't slip or come loose and are carefully pretested for smoothness, hardness and density.

Butterworth Calender Rolls are in constant use in America's leading paper mills giving superior finishes and outstanding service. Whether you require plain, embossing or glassine calenders, Butterworth Calender Rolls can be counted upon every time for top flight performance. Calender Rolls made in every size for all types of calendering. Furnished new or refilled.

For full information, write or call H. W. Butterworth & Sons Company, Philadelphia 25, Penna.—Providence Division, Providence, R. I. : : Charlotte, N. C., 1211 Johnston Building In Canada—W. J. Westaway Company, Hamilton, Ontario

Butterworth Calender Rolls

6. Mr. Calkin asked members of the Group to send any notices of personnel changes such as promotions, changes of position, change of address, etc. to William Landes, Paper and Pulp Testing Laboratories, 118 East 28 Street, New York 16, N. Y.

The main topic of this meeting was a talk on the "Future of the Small Mill" from the management viewpoint by Edward McSweeney of Perkins Goodwin Co. Mr. McSweeney has had a long and distinguished career in the industry. He served in the U. S. Navy in the first World War and as a consultant in Washington in the Second World War. Mr. McSweeney has acted as management consultant in the paper industry and in Graphic Arts. He is active in the American Management Association, a member of the Research Council of Lithographic Foundation, a trustee of Bard College, and a member of the committee on Finance Development of the Massachusetts Institute of Technology. At present he is Treasurer of Perkins Goodwin Co. of New York.

Although it is difficult to define a "Small Mill," the term is usually applied to the marginal high cost mill. Most of these mills were in fine financial condition during the war period when demand exceeded supply. Now, however, many of them will have to readjust to the present postwar period in which supply is catching up to and exceeding demand. The public in general is dubious of the progressiveness of pulp and paper mill management. This is borne out by the fact that pulp and paper securities are selling at 3 to 4 times earnings while those of other industries are selling at 4 to 5 times earnings. People are afraid to invest in pulp and paper companies.

The problems of the small mill may be listed as follows:

1. Periods of feast and famine in the paper business which are responsible for holding securities below those in other kinds of businesses.
2. Excessive per capita investment per ton or per worker.
3. Competition with the large companies that can produce at lower cost causing the marginal small mill to close.

One solution for the small mill is to produce specialties requiring special technical skill and leaving the production of staples to the big mill. The key to this may be found in a recent book by Egon Glesinger, "Coming Age of Wood" (Simon and Schuster, New York). The author outlines how the forest products industries under proper management can feed, clothe, and house the entire population and at the same time raise their living standards. New ideas and new products are suggested which open up entire new markets to progressive management. The small mill having the technical skill to put these new ideas into practice and a management alert enough to adjust to conditions as they exist, need not fear the future. With proper planning, the small mill can go in for specialization that the big mill cannot do. Technical skill in putting new products out on the market and resourcefulness in keeping step with progress can make a lasting place for the small mill in the industry.

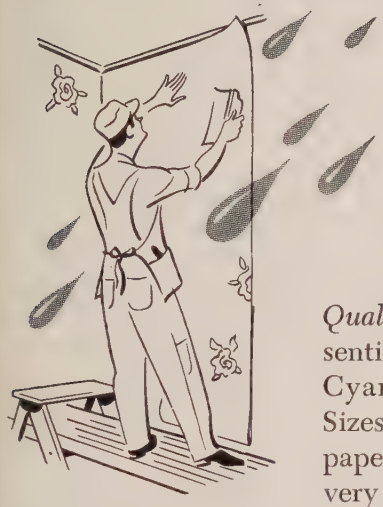
Another solution for the small mill is integration with a primary producer. The primary producer is one who manufactures for the consumer. He must have a large organization with research department, sales force, advertising departments, etc. Any one of the big automobile manufacturers fall into this category. The secondary producer is one who offers manufacturing service to the primary producer and rarely contacts the consumer directly. He will make a part or parts, as spark plugs for the automobile. The small mill is usually a secondary producer. With a seller's market, all secondary producers are in demand. However, when the market shrinks, the primary producer can tie up with one or two secondary producers or even make their own parts and do away with the secondary producer entirely.

(*Continued on page 48 A*)

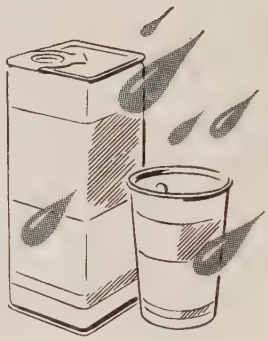
Paper Product Pointers
FROM CYANAMID

Re: Wider Markets for Paper...

ALWAX SIZES Improve Paper Quality
Impart Moisture Resistance And Pliability

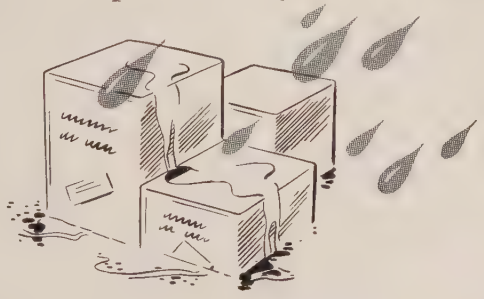


Quality . . . that's the essential ingredient which Cyanamid's ALWAX** Sizes bring to paper and paperboard. Often just a very minute quantity of ALWAX size added to the paper in the manufacturing process will improve the working qualities and increase the uses of the finished product. Pliability that facilitates crimping, scoring, creasing, folding or die-pressing; moisture-resistance that enables paper to withstand penetration by inks and other organic liquids – these are important contributions to the quality of paper.



In addition to ALWAX Sizes, Cyanamid has a complete line of paper chemicals developed with the dual aim of improving paper-making processes and imparting quality – a quality that *makes* the product and makes it *sell.*

Consult a Cyanamid representative about ALWAX Sizes and the many other quality-building chemicals in the Cyanamid line.



ALWAX** Sizes • WAXINE* Sizes • Rosin Size • PAREZ* Resins AZITE** Liquefier 900 • Synthetic Resins • Casein • Alum • Sulfonated Oils • Fillers • AEROSIZES** • Defoamers • Soda Ash • Caustic Soda Salt Cake • Acids • Clays • AEROSOL* Wetting Agents • CAL MICRO** (Calcium Carbonate) and other Paper Chemicals.

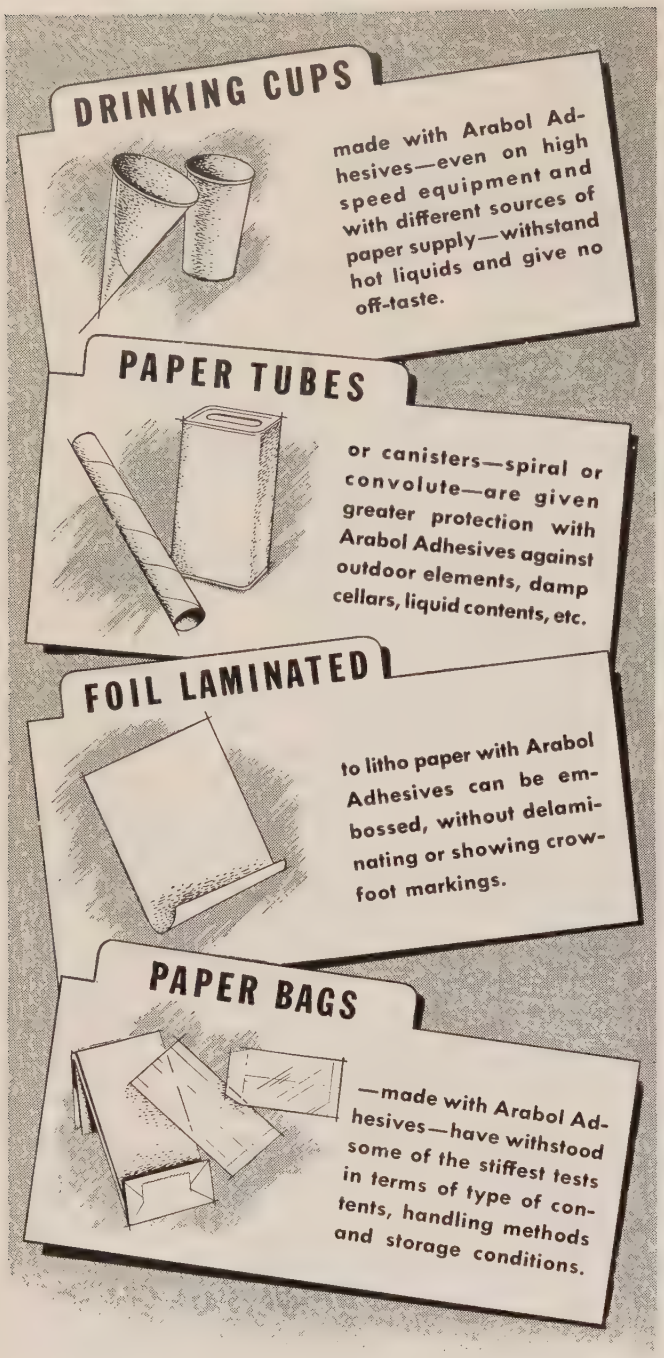
*Reg. U. S. Pat. Off. **Trade-mark

Sales Offices: Boston, Mass.; Philadelphia, Pa.; Pittsburgh, Pa.; Baltimore, Md.; Charlotte, N. C.; Cleveland, Ohio; Cincinnati, Ohio; Chicago, Ill.; Detroit, Mich.; Kalamazoo, Mich.; St. Louis, Mo.; Los Angeles, Calif.; San Francisco, Calif.; Seattle, Wash. In Canada: Dillons Chemical Co., Ltd., Montreal and Toronto.

AMERICAN Cyanamid COMPANY

INDUSTRIAL CHEMICALS DIVISION

30 ROCKEFELLER PLAZA, NEW YORK 20, N. Y.


DRINKING CUPS
made with Arabol Adhesives—even on high speed equipment and with different sources of paper supply—withstand hot liquids and give no off-taste.
PAPER TUBES
or canisters—spiral or convolute—are given greater protection with Arabol Adhesives against outdoor elements, damp cellars, liquid contents, etc.
FOIL LAMINATED
to litho paper with Arabol Adhesives can be embossed, without delaminating or showing crowfoot markings.
PAPER BAGS
—made with Arabol Adhesives—have withstood some of the stiffest tests in terms of type of contents, handling methods and storage conditions.

Your Arabol Representative has the backing of his company's long experience in serving the leaders of more than a hundred industries. Let him suggest ways whereby Arabol Adhesives can speed up your production and increase the protection of your product. Some problems can be solved right in your own plant in one day's time. Three laboratories are available for more complicated problems.

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Executive Offices: 110 East 42nd St., New York 17, N. Y.

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Adhesives?... **ARABOL!**

The small mill must study the possibilities open to it. It can become a primary producer by putting out a new product and marketing it itself. It can remain a secondary producer but become connected with a primary producer by buying into it or selling into it. This may be advantageous to both. The primary producer is assured of the "know how" of the secondary producer, whereas the secondary producer obtains a ready-made sales organization in the primary producer. Another form of integration can be achieved by the cooperation of a number of small mills in bringing their product to the selling agent. Although some small mills dislike this form of integration, the selling agent can be of great service to them. Producing for a small geographical area may be a possibility. This might be called an integrated market as the New England area. Recent discussion on Basing Point Pricing and other such topics are vital factors in the survival of the small mill. Which road to take is a problem that each mill must decide for itself. The small mill must make an honest appraisal of its condition and put on paper its past and its present and from this plan for the future.

Question: The question of primary producer and secondary producer is confusing. The primary producer makes consumer goods. The secondary producer renders manufacturing service. How can a paper mill become a primary producer when it makes printing paper?

Answer: There is a trend in the magazine industry to buy up paper mills. The small mill which is not sure of its future can go to the magazine publisher and ask him to tie up with him or the magazine publisher to assure himself of a steady supply may buy up a paper mill. This is integration of primary producer and secondary producer.

Question: (comment from floor)

From my experience in the paper industry in Europe, the small mill under good management can survive by making specialties. The big mills cannot make what the small mills can just as the small mills cannot make what the big ones do. In Europe many small mills survived by combining with a converting mill or by going into the converting business by opening such a department.

Question: How much of the future of the small mill depends upon its merchandising policy?

Answer: There is no such connection. It does not depend upon its mechandising policy as such. During the past few years the paper industry was in the hands of the technical man whose one problem was more production. Today policy making is most important. The three important factors in the industry are: (1) operation in the hands of the technical man, (2) policy determination-planning the future of the business, and (3) management control-balancing of operation and policy determination for a successful future.

Question: The small mill cannot make staple items but must turn to specialties. These require a high degree of technical skill which is not usually available to the small mill. How can they obtain this technical skill?

Answer: There are two ways: (1) compete for and pay for the best technical skill, or (2) make use of technical skill available for hire in the form of consultants.

Question: Do you feel that the small mill can use the mill agent to achieve integration?

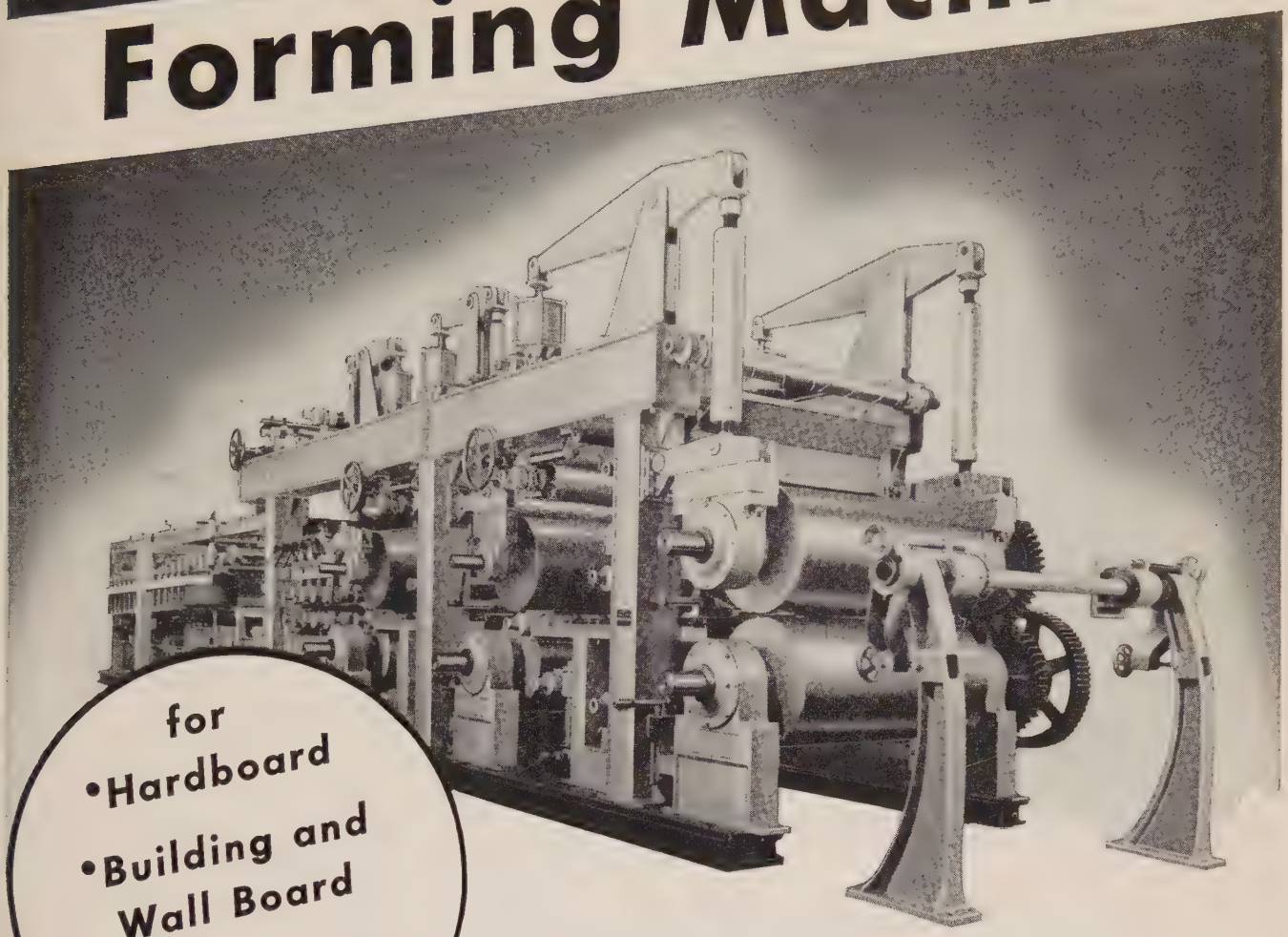
Answer: I was referring to the selling agent. Yes, the selling agent can help the small mill by providing business advice, technical advice, financial help, market advice, etc. The selling agent should do more than just sell.

Question: Are there any such selling agents as you describe in existence?

Answer: No, there is an opportunity for someone in the future. Because of the war period, the selling agent lost his identity and his personal interest in the mill.

(*Continued on page 50 A*)

Sandy Hill Forming Machine



for
- Hardboard
- Building and Wall Board
- Coarse Fiber Boards

- **Silicon Bronze Headbox provides uniform thickness**
- **Adjustable Vibrator provides stock leveling action**

Proven successful in numerous installations, this improved Hardboard Machine is the product of Sandy Hill's sound engineering and production skill. Stock is introduced through a silicon bronze headbox specifically engineered to regulate the flow to provide uniform thickness across the wire. A secondary headbox, adjustable along the overhead framing, is suspended over the fourdrinier, providing a method of applying another stock to the sheet already being formed.

An adjustable vibrator is suspended between primary and secondary headbox to give additional stock leveling action. To maintain a seal and true edge on the forming sheet, a non-corrosive deckle strap arrangement is suspended at proper intervals.

Two flat suction boxes, a two-section Rotabelt and a patented Kamyr suction box assure a high degree of water removal from the sheet before the presses.

Many other typical Sandy Hill quality features are included. Let us give you further information pertaining to your individual mill requirements.

Sandy Hill Iron & Brass Works

Hudson Falls, N. Y.

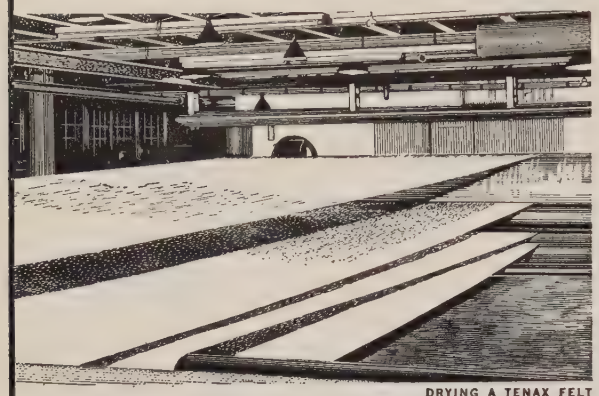
Machinists and Founders Specializing in Paper and Pulp Mill Machinery

Manufacturers of

Adjustable Cylinder Vats
Cylinder Paper Machines
Pulp Grinders
Dandy Roll Drives
Pulpers or Kneaders, Voith
Thickeners
Quick Opening Gate Valves
Bertrams Flow Distributors
Bertrams Shakes
Neilson Slice
Feltless Wet Machines
"Selective" and Corner Drives
Fourdrinier Paper Machines
"Packer" Screens
Castings
Bleaching Equipment
Scofield Felt Conditioners
Cleveland Type Bearings
Shaker Screens

TENAX FELTS

—lower your operating costs
—by increasing the efficiency of your paper-making machines.



DRYING A TENAX FELT

Experts, with many years experience, carefully supervise each phase of production in the Lockport Mill. All their efforts serve to give you felts most suited to your paper-making needs.

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LARGE WATER SUPPLIES

Contrary to popular belief, a large water supply does not necessarily mean an expensive one. There are many municipal and industrial sites in this country which are located near underground water supplies of considerable magnitude. These particular sites can afford large but inexpensive water supplies if properly developed by the Ranney Method of Water Collection. Whether your particular site is near a small or large ground water supply can be predetermined accurately by our engineering staff who are ground water specialists.

Your inquiry would be welcome.

RANNEY METHOD WATER SUPPLIES, INC.

Ranney Water Collector Corporation of New York

Water Supply Engineers & Contractors

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Question: Is it possible that the future of the pulp and paper industry is in new outlets or new fields through TAPPI?

Answer: There are two kinds of industries: (1) those that were old when science began, and (2) those that were born from science. The paper and pulp industry belongs to both groups. Whereas scientific businesses have attracted the best engineers, the paper industry has only started to hire men of science. Yes, there are great possibilities for the future for developments due to science.

Mr. McSweeney brought the meeting to a close by quoting from Kettering, "My interest is in the future because I am going to spend the rest of my life in it."

WILLIAM LANDES

PAPER MILL MODERNIZATION

The regular monthly meeting of the Western New York Group, Empire State Section of TAPPI took place on April 13th at the Prospect House in Niagara Falls, N. Y.

About 40 members were present to hear Russell C. Shearer, Manager of the Merritton Division of Alliance Paper Mills, Ltd. talk on the subject of "Paper Mill Modernization." Mr. Shearer used a new approach to an old subject, stressing particularly the part that mill personnel must play in analyzing mill conditions, in studying economic trends and sales direction, in carefully reviewing the overall picture as regards location, geography, raw materials, power and stock preparation ability. Modernization in thinking by mill personnel is, according to Mr. Shearer, the primary requisite in any mill modernization program, and embraces a multitude of factors which, unless they are intelligently provided for, will cancel out whatever advantages might have accrued from step-wise planning. The progressive examination of equipment to ensure balance of ability and the planning in stages to most benefit earning power should be the first consideration in capital expenditure for mill improvement, although the approach is, of course, dictated by the innate potentialities of the mill itself and by a determination of quality and quantity required to fit the sales market.

Mr. Shearer pointed out that all too often a "cart before the horse attitude" prevails in new equipment installations and that underestimating or poor planning, when multiplied by twenty years' operation, assumes an importance out of all proportion to what it appears to have when considered only from the immediate viewpoint. This multiplication factor can likewise be applied to point up the cost of poor mechanical maintenance of existing equipment, of poor supervision or of failure to utilize to the fullest the equipment at hand. In this connection, lost time analyses and summaries, studies of the maintenance organization as related to the lost time analysis, production control, and establishment of suitable standards are invaluable aids in improving operations and getting the most out of existing equipment. The extreme breadth and complexity of the problem of mill modernization demand a most careful study before any steps are taken, Mr. Shearer said, pointing out, however, that it is this very complexity which in its far-reaching results pays dividends when careful planning is the basis for the modernization program.

Dr. J. S. Reichert of du Pont de Nemours, Niagara Falls, N. Y., presided, and announced the appointment of a nominating committee, headed by Mr. J. W. Youngchild, who will present a slate of officers for the coming year at the May 11th meeting.

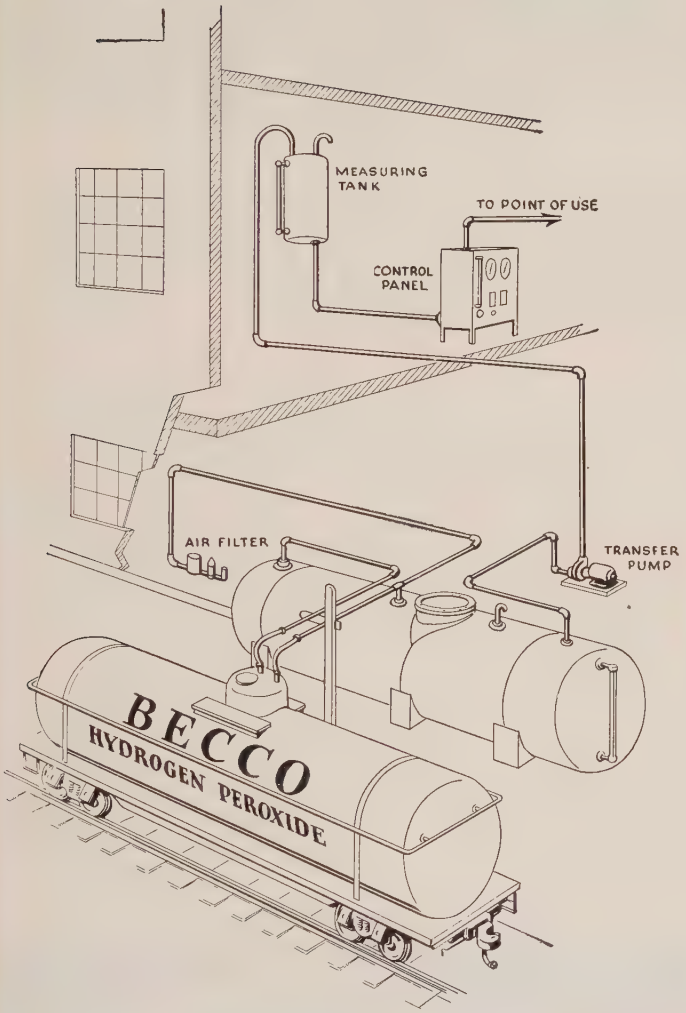
Maine-New Hampshire

The annual meeting of the Maine-New Hampshire Section will be held at the Wentworth-by-the-Sea, Portsmouth, N. H., on June 17–18, 1949. H. E. Pratt, Pejepscot Paper

(*Continued on page 52 A*)

ADD (+) to PRODUCTION
SUBTRACT (–) from COSTS

with



LIQUID BECCO HYDROGEN PEROXIDE

in BULK SHIPMENTS and BULK STORAGE

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Originators of bulk shipments of hydrogen peroxide, Becco, for 18 years has been providing the industry with efficient, money-saving installations. Becco's fleet of tank cars . . . largest in the hydrogen peroxide field . . . provides prompt service.

Becco's representatives will be pleased to discuss with you the most efficient layout for the storage and use of H_2O_2 in your plant.

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Who are these well-known individuals? You know some of them as well as we do. So for the record let us divulge: 1949 Annual Conference, Paper Chemicals Dept., American Cyanamid Co., Stamford, Conn. Seated from left to right in the enclosed photograph are:—Messrs. C. G. Landes (Stamford); R. W. Kumler (New York); C. F. Bonnet (New York); E. H. Northey (Administrative Director, Stamford Laboratories); A. J. Campbell (General Manager, Industrial Chemical Division—New York); J. M. Walsh (New York); J. D. Lowery (New York); W. H. Harding (Stamford); H. G. McCormack (Baltimore); A. C. Bate (Boston).

Standing:—Messrs. A. M. Asherman (New York); J. C. Pullman (Stamford); E. J. Meier (Stamford); W. M. Wooding (Stamford); H. G. Pratt (Los Angeles); R. Hastings (Stamford); W. F. Reynolds (Stamford); C. A. Mehl (New York); W. P. Spielman (Stamford); D. W. Jayne Jr. (Stamford); R. O. Lindsey (Boston); L. H. Wilson (Stamford); D. D. Ritson (Stamford); F. A. Strovink (Boston); H. A. Sinclair (Kalamazoo); L. J. O'Neill (Waterbury); A. Klipstein (New York); G. D. Lord (Philadelphia); E. J. Adams (Birmingham); R. S. Meade (Charlotte); J. C. Barthel (Stamford); C. S. Maxwell (Stamford); R. A. Skelton (Mobile); F. R. Boyle (New York); A. W. Ayles (Wausau, Wis.); J. Hunter (Charlotte); L. S. Simser (Appleton, Wis.); J. A. Leek (New York); G. Fromm (New York); J. Wellman (Kalamazoo); R. N. Prince (Albany, N. Y.); J. R. Verdon (Kalamazoo); A. Sabina (Stamford); T. F. Thierry (New York); J. Brown (New York). Not present:—K. E. Youngchild (New York).

Co., Brunswick, Maine, is Chairman of the Section and will supply a copy of the program to nonmembers of the Section who may be interested in attending this meeting. The June issue of *Tappi* will go to press too late to provide this information. The program will also be published in the trade papers.

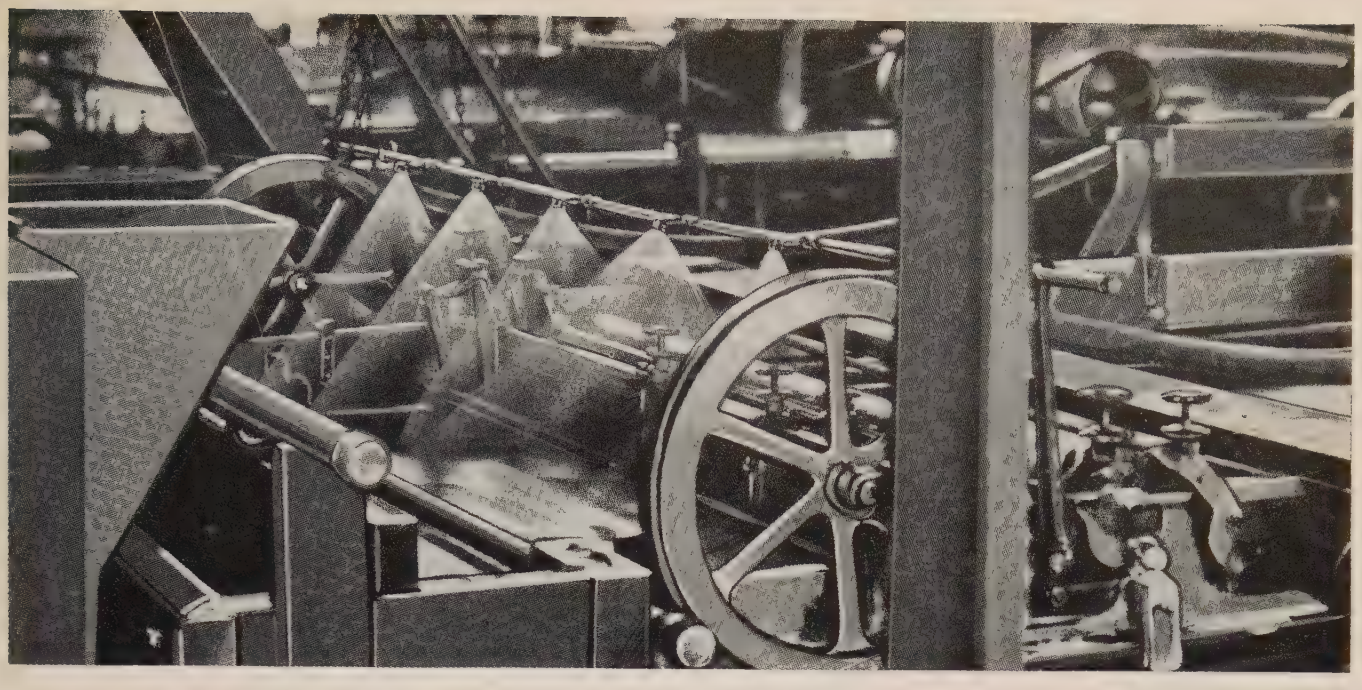
Lake States

The Lake States Section met at the American Legion Clubhouse, Appleton, Wis., on April 12, 1949. The speaker was Ferdinand Kraft, Technical Director of the Marathon Paper Mills of Canada, Ltd., Marathon, Ont. Dr. Kraft discussed the various operations of his mill in Canada.

General

Officers of local sections are requested to review these reports of activities of the various Sections. The magazine began publication midway during the regular series of meetings this year and consequently the reporting has not been as good as it probably will become by next fall when the Sections resume their meetings.

It is important for publicity committees, Secretaries, and other reporters to keep in mind that meeting reports should be received by the *Tappi* staff prior to the 15th of the month and should be in final form. Some Sections may have been disappointed in the reports that have been published this spring or, more to the point, not published. The form and condition of many reports have been such that the editor has pondered the material for some time before reluctantly giving up the rewrite job. The time available is so short and there are so many other things to do, that an inadequate section report has to be discarded, for the time being, at least. It is very easy to do a good job of reporting. Just remember to answer the questions Who—when—where—what? Keep in mind that a large proportion of our members want to know "what the man actually said."



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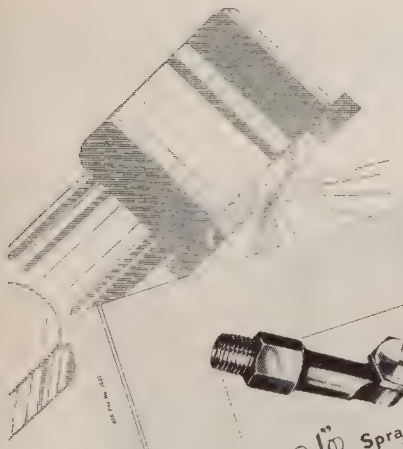

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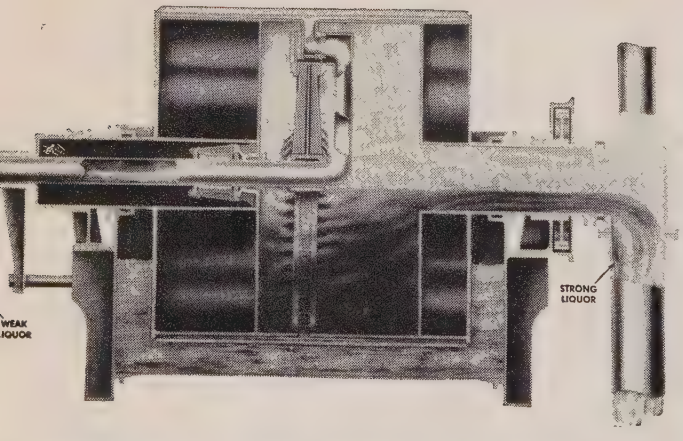
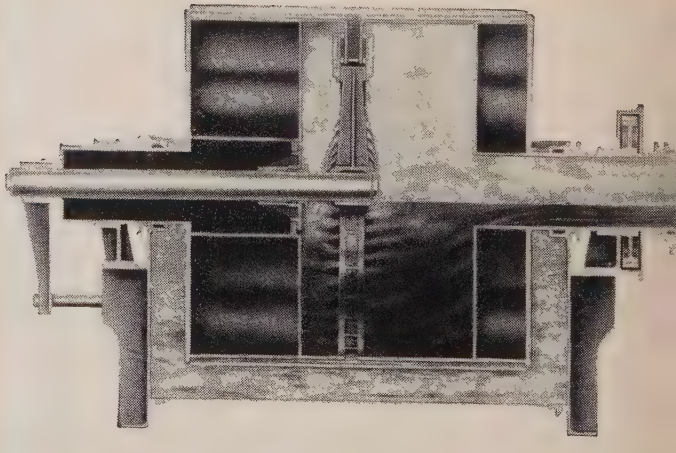
ALL ADD UP TO

16 OLIVER "RINGVALVE"





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PERSONAL MENTION

Items About New and Old Tappimen

New TAPPI Members

John H. Ainsworth, Technical Supervisor, Bloedel, Stewart & Welch Ltd., Pulp Div., Port Alberni, B. C., Canada.

Russell W. Allgood, Section Manager, Canadian Industries Ltd., Montreal, P. Q., Canada, a 1941 graduate of the University of Toronto with a Ph.D. degree.

Gerald L. Barthauer, Laboratory Director, The Stevens Paper Mills, Inc., Westfield, Mass., a 1943 graduate of Purdue University with a Ph.D. degree.

Charles H. Benbrook, Manager, Quality Control and Research, Ozalid Div., General Aniline & Film Corp., Johnson City, N. Y., a 1933 graduate of the University of Colorado with an M.S. degree.

Alexander F. Bobreski, Student, New York State College of Forestry, Syracuse, N. Y.

Arthur W. Brown, Vice-President, Brown-Hutchinson Iron Works, Detroit, Mich.

Lawrence H. Brown, Chemist, St. Regis Paper Co., Kalamazoo, Mich., a 1948 graduate of the New York State College of Forestry.

Wilhelmine L. Brown, Librarian, Solvay Process Div., Allied Chemical & Dye Corp., Solvay, N. Y., a 1943 graduate of Syracuse University.

William H. Byron, Student, New York State College of Forestry, Syracuse, N. Y.

Ragnar Carlgren, Chemist, W. F. Hall Printing Co., Chicago, Ill., a 1924 graduate of Falu Bergsskola, Sweden.

William A. Childs, Jr., Instrument Technician, Container Corporation of America, Fernandina, Fla., a 1939 graduate of Georgia School of Technology.

Henry E. Coomber, Senior Experimental Officer, Imperial Institute, London, England, a 1927 graduate of King's College, London.

Charles R. Cosby, Executive Secretary, Label Manufacturers National Assn., Washington, D. C., a 1922 graduate of San Francisco College, and a 1923 graduate of San Francisco Law School.

Paul M. Coty, Coordinator, Ozalid Div., General Aniline & Film Corp., Johnson City, N. Y.

Richard J. Coveney, Chief Research Engineer, Fram Corp., Providence, R. I., a 1929 graduate of Massachusetts Institute of Technology.

Harold E. Cunningham, Manager and Chief Engineer, Dominion Engineering Co. Ltd., Lachine, P. Q., Canada, a 1931 graduate of McGill University.

John R. Curtis, Plant Engineering Manager, Scott Paper Co., Chester, Pa., a 1935 graduate of Johns Hopkins University.

Edwin C. Daniels, Student, New York State College of Forestry, Syracuse, N. Y.

Francis R. Davenport, Technical Assistant to Chairman, Tissue Papers Ltd., London, England, a 1940 graduate of University College, Nottingham.

William J. Elkins, Sales Engineer, Moore & White Co., Philadelphia, Pa., a 1925 graduate of Cornell University.

Walter P. Ericks, Director of Research, The Upson Co., Lockport, N. Y., a 1935 graduate of University of Buffalo with a Ph.D. degree.

Seymour W. Ferris, Chief, Wax Section, Sun Oil Co., Marcus Hook, Pa., a 1922 graduate of Cornell University.

Jacques Francois, Manager, S. A. des Papeteries de Huyssinghen, Huyssinghen, Belgium, a 1940 graduate of Brussels University.

Paul J. Frost, Chemical Engineer, New York & Pennsylvania Co., Inc., Johnsonburg, Pa., a 1944 graduate of the University of British Columbia.

Wilfred Gallay, Director of Research, The E. B. Eddy Co., Hull, P. Q., Canada, a 1927 graduate of McGill University, with a Ph.D. degree in 1930.

Richard J. Grimm, Chemist, St. Regis Paper Co., Deferiet, N. Y., a 1949 graduate of Seton Hall.

William M. Hearon, Supervisor, Fundamental Research, Crown Zellerbach Corp., Camas, Wash., a 1935 graduate of the University of Denver, with a Ph.D. degree from Massachusetts Institute of Technology in 1947.

Charles J. Haug, Manager of Production, Anton J. Haug, Nashua, N. H., a 1947 graduate of the University of New Hampshire.

Arnoldus A. M. Helmich, Manager, Paperindustry Superieur Ltd., Schiedam, Holland.

Albert M. Hendricks, Technical Adviser, Hopper Paper Co., Reading, Pa., a 1939 graduate of James Millikin University.

Raymond E. Hess, Technical Secretary and Editor, American Society Testing Materials, Philadelphia, Pa., a 1919 graduate of University of Pennsylvania.

William H. Holl, Production Manager, The Victoria Paper Mills Co., Fulton, N. Y. a 1928 graduate of Pennsylvania State College.

Frederic C. Holmes, Chief Engineer, Smith Paper, Inc., Lee, Mass., a 1931 graduate of Worcester Polytechnic Institute.

Gerald W. Hough, Student, New York State College of Forestry, Syracuse, N. Y.

Alfred M. Hurter, Project and Process Engineer, Stadler, Hurter & Co., Montreal, P. Q., Canada, a 1946 graduate of McGill University.

J. Hutton, Research Officer, Library and Information Div., Council for Scientific and Industrial Research, Pretoria, S. A.

Arthur W. Infanger, Chief Engineer, The Cowles Co., Cayuga, N. Y., Attended Syracuse University.

Everett P. Ingalls, Jr., Paper Machine and Beater Foreman, S. D. Warren Co., Cumberland Mills, Me., a 1943 graduate of University of Maine.

Harold L. Jones, Research Associate, The Institute of Paper Chemistry, Appleton, Wis., a 1934 graduate of Oglethorpe University with an M.S. degree.

Joseph B. Kindleberger, Vice-President, Kalamazoo Vegetable Parchment Co., Kalamazoo, Mich., a 1927 graduate of Babson Institute.

Bernard J. Koziol, Plant Engineer, St. Regis Paper Co., Deferiet, N. Y., a 1942 graduate of Clarkson College of Technology.

Otto E. Lohrke, Jr., Chemist, Riegel Paper Corp., Milford, N. J., a 1947 graduate of Princeton University.

Donald G. Magill, Jr., Chemist, Riegel Paper Corp., Milford, N. J., a 1945 graduate of Yale University, with an M.S. degree from Lehigh University in 1948.

Stanley A. Mathys, Laboratory Technician and Colorist, The J. P. Lewis Co., Beaver Falls, N. Y.

David M. Misner, Sales Engineer, C. R. Swaney Co., Boston, Mass., a 1938 graduate of Cornell University.

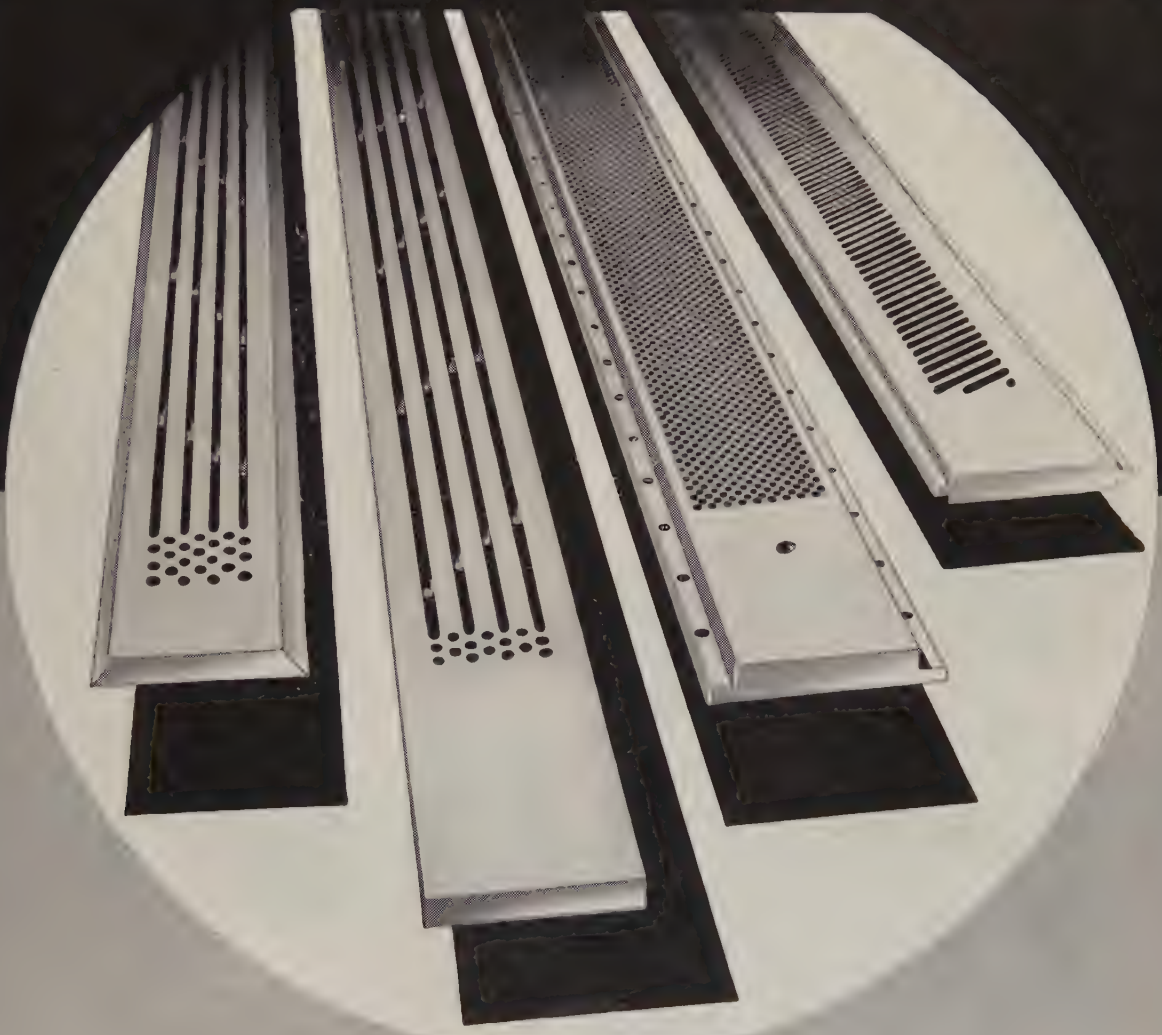
Merrill R. Morrison, Digester Cook, Weyerhaeuser Timber Co., Longview, Wash.

Alfred E. Moyer, Assistant to President, Snyder Chemi-

(*Continued on page 58 A*)

LODDING

Panelyte Suction Box Covers



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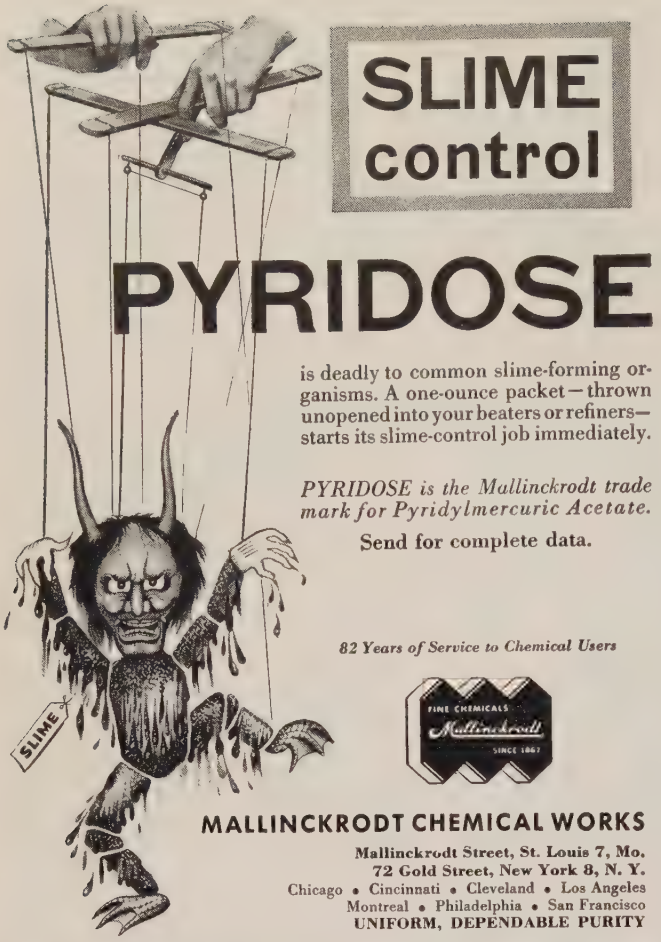
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cal Corp., Bethel, Conn., a 1942 graduate of the University of Buffalo.

G. Flint Purdy, Director of Library Service, Wayne University, Detroit, Mich., a 1936 graduate of the University of Chicago with a Ph.D. degree.

Jesse M. Robinson, Chemist, Champion Paper & Fibre Co., N. C., a 1948 graduate of North Carolina State College.

Ted R. Robinson, Secretary and Manager, Robinson Plywood & Timber Co., Everett, Wash., a 1922 graduate of the University of Washington.

Nevin B. Rohrbaugh, Plant Engineer, P. H. Glatfelter Co., Spring Grove, Pa., a 1936 graduate of Pennsylvania State College.

David A. Royer, Jr., Chemist, The Ohio Boxboard Co., Rittman, Ohio, a 1947 graduate of Mt. Union College.

Paul K. Schilling, Research Assistant, Keyes Fibre Co., Waterville, Me., a 1947 graduate of Massachusetts Institute of Technology.

David C. Scott, Jr., Assistant Treasurer, Scott Testers, Inc., Providence, R. I., attended Massachusetts Institute of Technology.

Biswanath Sen, Student, The Institute of Paper Chemistry, Appleton, Wis., a 1945 graduate of the University of Calcutta, with an M.S. degree.

George E. Smedberg, Engineer, E. I. du Pont de Nemours & Co., Inc., Niagara Falls, N. Y., a 1942 graduate of the University of Wisconsin with a Ph.D. degree.

Francis H. Snyder, President and Technical Director, Snyder Chemical Corp., Bethel, Conn. Attended Syracuse University.

Lazarus Spiwak, Manager, Technical Service and Development, Snyder Chemical Corp., Bethel, Conn., a 1942 graduate of the City College of New York with an M.S. degree.

Phillip L. Staats, Chemist, General Electric Co., Pittsfield, Mass., a 1942 graduate of the University of Toronto.

Herbert C. Stecker, President and Treasurer, Stecker Chemicals, Inc., Ridgewood, N. J., a 1939 graduate of the University of Wisconsin, with a Ph.D. degree from the University of Cincinnati in 1942.

Willard I. Stinger, Process Development Supervisor, Chemical Div., Marathon Corp., Rothschild, Wis., a 1937 graduate of the University of Minnesota.

Katharine M. Stokes, Head Librarian, Western Michigan College, Kalamazo, Mich., a 1945 graduate of the University of Michigan with an M.A. degree.

Jacques F. Tasiaux, Assistant Manager, Continental Cellulose S. A., Brussels, Belgium, a 1948 graduate of the Institute of St. Ignace, Antwerp.

Thomas D. Tierney, Consulting Engineer, A. J. Rauh & Co., Houston, Tex., a 1948 graduate of Rhode Island State College.

William L. Tilley, Groundwood Superintendent, St. Regis Paper Co., Bucksport, Me. Attended Bowdoin College.

Donald I. Walker, Lubrication Engineer, Standard Oil Co., (Indiana), Chicago, Ill., a 1933 graduate of Grinell College.

Ruth M. Watts, Research Chemist, Pulp Div., Weyerhaeuser Timber Co., Longview, Wash., a 1925 graduate of Yale University with an M.S. degree, and a Ph.D. degree from the University of Chicago in 1930.

Jack E. Wilber, Chemical Engineer, St. Regis Paper Co., Kalamazoo, Mich., a 1948 graduate of Clarkson College of Technology.

Arthur R. Williams, Acting Superintendent, New Brunswick International Paper Co., Dalhousie, N. B., Canada, a 1942 graduate of Queen's College.

Mortimer J. Williams, Trainee, Robert Gair Co., Inc., Tonawanda, N. Y., a 1948 graduate of the University of Maine.

(*Continued on page 60 A*)

THE *Complete* STORY ON THE *Complete* REX LINE

Here's the complete story on the complete Rex line of pulp and paper mill chains. Bulletin No. 48-27 gives you all the facts . . . specifications, dimensions, list prices plus important data on Rex quality features. There's page after page of application photographs . . . interesting views of Rex Chains at work in mills from coast to coast.

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ARWAX POLYETHYLENE CONCENTRATES

For grease-resistance and gloss PLUS higher blocking temperature . . . higher tensile strengths.

Recommended Uses

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Similar to ARWAX Vistanex concentrates but lower cost and easier to handle . . . Improves adhesion and flexibility of paraffin and microcrystalline waxes.

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TAPPI Notes

J. C. Aggarwalla, who has been visiting in the United States has returned to the Shree Gopal Paper Mills, Ltd., Abdullapur, India.

Ralph T. Casselman, formerly of Higgins Plastics is now with Paine Lumber Co., Ltd., Oshkosh, Wis.

Ben King Duffy of the General American Transportation Corp. is now the Company representative to handle sales of plate and welding in their Process Equipment Division in the Pittsburgh District.

George S. Edwards, Chemical engineer for the Swenson Evaporator Co. has been transferred from Harvey, Ill., to Birmingham, Ala.

M. L. Edwards, formerly of the Weyerhaeuser Timber Co., is now consulting engineer for Thompson Products, Inc., Cleveland, Ohio.

Alfred T. Gardner, formerly paper mill superintendent of the Crown Zellerbach Corp., is now with Provincial Paper Ltd., Mille Roches, Ont.

G. Emil Haeger, formerly graduate student at the N. Y. State College of Forestry, is now superintendent, Inlands A/B., Lilla Edet, Sweden.

James H. McClure of the St. Regis Paper Co. has been transferred from Kalamazoo, Mich., to Deferiet, N. Y., as Division Industrial Engineer of the Printing, Publication and Converting Paper Division.

George McTeague, formerly of the Smith Paper Co., is now technical secretary for Cia Industrial de Papel Pirahy, Rio de Janeiro, Brazil.

Rae H. Mills, formerly of J. E. Sirrine & Co., is now engineer for the Hudson Pulp and Paper Corp., Palatka, Fla.

Maurice O. Neilson, formerly of the Champion Paper Mills, Ltd., is now with Krumm, Young Co., Ltd., Thorold, Ont.

C. P. Olstad, formerly of Canada Foils, Ltd., is now plant superintendent, Minerva Wax Paper Co., Minerva, Ohio.

Merle B. Shaw, after thirty years of service in the Paper Section, National Bureau of Standards where he participated in its fine work for the paper industry has retired and plans to return to live in Maine.

George E. Soyka, formerly of the Missisquoi Corp., is now technical director, Fort Orange Paper Co., Castleton-on-Hudson, N. Y.

Roger L. Steller, technical representative for the B. F. Goodrich Chemical Co., has been transferred from Cleveland, Ohio to Boston, Mass.

Paul J. Thoma, consultant for Time, Inc., has been transferred from Kalamazoo, Mich., to the Springdale, Conn., Laboratory.

William F. Underwood, formerly of E. I. du Pont de Nemours, Inc., is now chief chemist, Clearing Div., The Visking Corp., Chicago, Ill.

Charles W. White, chemical engineer for the Pacific Coast Borax Co., has been transferred from Chicago, Ill., to Cleveland, Ohio.

Clayton B. Willis, formerly chemist for the Container Corp. of America, is now with the Industrial Specialties Co., Fort Worth, Texas.

Anthony J. Wirpsa, formerly with the Racquette River Paper Co., is now supervisory chemist for paper products for E. F. Houghton & Co., Philadelphia, Pa.

W. R. Zwecker is now President of the Saugerties Paper Mills, Inc., Saugerties, N. Y.

M. A. Dixon, manager of lubricating and industrial sales for Standard Oil Co. (Indiana), has succeeded H. J. Saladin (deceased) as official representative of the Company in the Technical Association.

Herman L. Kutter

H. L. Kutter, former president of The Black-Clawson Co., Hamilton, Ohio, died at the age of 77, in that city on March 2. To the time of his retirement, he had been associated with the company in various capacities for an even half century. After relinquishing the presidency in 1946, he continued serving as a director until his death. He came to the United States in 1891 at the age of 19. He was already a paper maker, having started to work in early boyhood in a European mill producing currency paper and other all-rag papers. He held engineering positions with several American paper companies before joining Black-Clawson in 1896. He became secretary of the company in 1911, general manager in 1923, president in 1930. His primary interest in paper making was engineering. He memorialized himself in the industry by contributing many improvements to paper machines.

Edward A. Weber

Edward A. Weber, sulphite superintendent for the Oregon Pulp and Paper Co., Salem, Ore., died on March 24th of a heart attack. Mr. Weber was born in Konigsburg, Germany on September 9, 1879. He came to America in 1903 as asst. supt. of the International Paper Co. sulphite mill at Palmer, N. Y. In 1905 he took a similar position at the Newton Falls Paper Co., Newton Falls, N. Y. From 1907–27 he was sulphate and sulphite pulp mill superintendent for the Central Paper Co., Muskegon, Mich. In 1928 he helped in the reconstruction of the mill at Port Mellon, B. C., and joined the Oregon Pulp and Paper Co. He is survived by his son F. E. Weber of Salem, Ore.

(*Continued on page 62 A*)

field engineering

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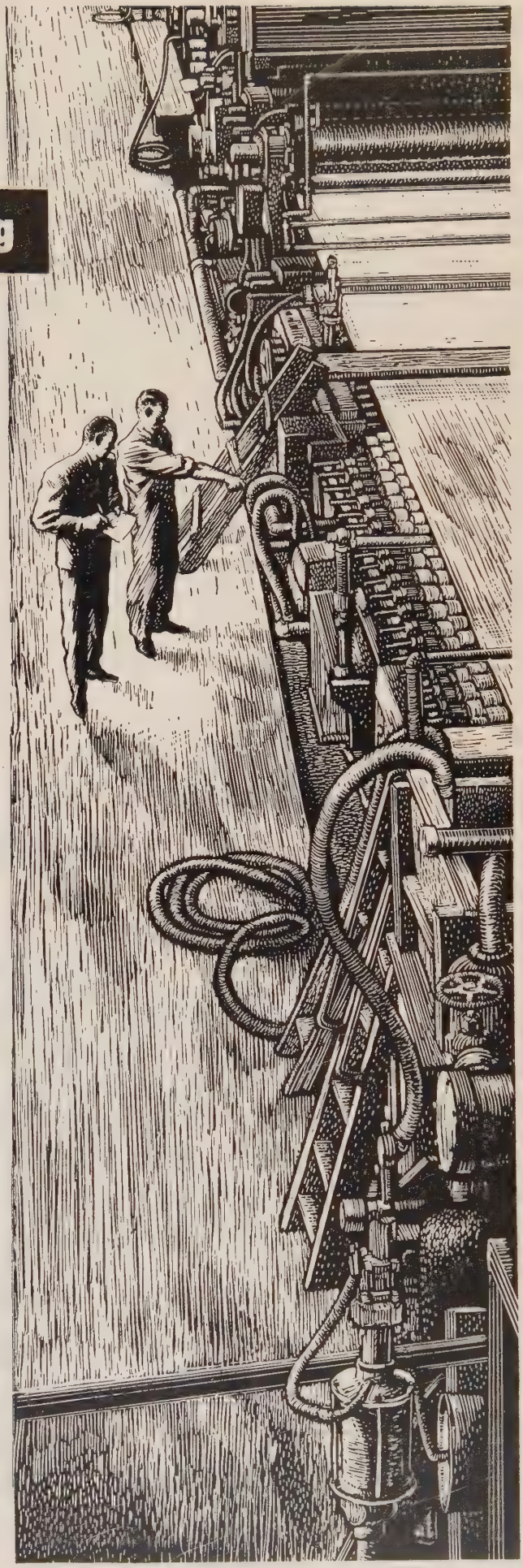

APPLETON WIRE WORKS, INC.

APPLETON, WISCONSIN

OBITUARIES

(*Continued from page 60 A*)

Sanford E. Thompson

Sanford E. Thompson, President of Thompson & Lichtner Co., Boston, died on February 25 at Phoenix, Ariz. Funeral services were held on March 2 at the Newton Highlands Congregational Church, Newton Highlands, Mass.

Mr. Thompson was born in Ogdensburg, N. Y., on Feb. 13, 1867, and graduated in civil engineering from the Massachusetts Institute of Technology in 1889. He is survived by his wife, Frances Lord March, and daughters Dr. Dorothy Thompson and Mrs. Ward Beckwith.

Mr. Thompson had a long and successful career as a civil and management engineer. He was one of the founders of the Taylor Society and was a member of many societies, including the Technical Association of the Pulp and Paper Industry. With Frederick W. Taylor he was the author of a number of treatises on concrete. He presented two papers at TAPPI annual meetings: "Improved Paper Quality Through Incentives" and "A Brief Survey of Management Methods in Paper Mills."

Robert Woods Van Kirk, Jr.

Robert Woods Van Kirk, Jr., was born at Ypsilanti, Mich., June 19, 1896, the son of the Rev. Robert Woods Van Kirk and Grace Warren Van Kirk. He attended grade school in Jackson, Mich.; high school in Newton Centre, Mass., and was graduated in 1918 from the Massachusetts Institute of Technology as a chemical engineer. He was president of his senior class and a member of Phi Beta Epsilon fraternity.

Mr. Van Kirk began his business career with the E. I. du Pont Co. in their Wilmington, Del., plant, later representing them as a salesman in their Dyestuffs Division, working out of the Chicago office, covering paper mills in the mid-west. Since 1931 he had been associated with Penick & Ford, Ltd., Inc., of Cedar Rapids, Iowa, in a similar capacity. He was widely known in the paper trade.

He is survived by his widow, Lorraine; two daughters, Alice and Mary Louise, and a son, Robert Woods 3rd. He also leaves a sister, Mrs. N. F. George of Phoenix, Ariz., two brothers, Warren of Rochester, N. Y., and Gordon of Altadena, Calif. Mr. Van Kirk lived at 2502 Park Place, Evanston, Ill.

RECENT BOOKS

Package Engineering Handbook. By Walter Stern, Packaging Director, Barnes & Reinecke, Inc., Board Products Publishing Co., 228 N. La Salle St., Chicago, Ill. 1949. Cloth, $8^3/_4 \times 10^3/_4$, 175 pages. Illustrated. $7.50 domestic, $8.50 foreign.

Readers of "Fibre Containers" have had the benefit of reading the chapters of this book as they were published in serial form. It is likely that a large number welcomed the opportunity to purchase the collated material in the form of a cloth-bound book.

Packaging has become a subject of vital concern to all manufacturers in recent years. During the war the mechanics of packaging attained a high degree of development and the tremendous attendance at the various packaging expositions is significant. In peace time emphasis is given to the package as a sales promoter. It is remarkable that so much interest can be displayed in the design of a box.

This book of seven chapters is a guide to information of value to every manufacturer. It indicates the organizations that are working in this field. It tells how to write package specifications and contains many useful reference tables such as basis weight conversion, boxboard standards, wrapping paper yardage, etc. Its Chapter 4 on The Tools of Package Engineering covers adhesives, bags, and sacks, cover papers, cans, tubes, crating, folding and set-up boxes, palletizing, taping, etc.

Tappi is glad to draw the attention of its readers to this convenient handbook.

Trade Marks. By H. Bennett, Technical Director, Glyco Products Co. Inc. Chemical Publishing Co., Brooklyn, N. Y. Cloth, $5^1/_2 \times 8^3/_4$, 479 pages. $10.

Interest in the "Lanham Act" has attracted much interest lately to the significance and importance of trade marks. Many legal interpretations have been published. Mr. Bennett's book, like several others that he has written, is an attempt, with success, to popularize the subject for the benefit of industry executives. It outlines the principles of trade mark selection and demonstrates the four different ways of coining original names. The chapter on legal aspects indicates the importance of employing an attorney to assist in making the final decision. A major part of the book is a dictionary of trade names with a careful analysis of the ways in which these have been selected.

Copies may be purchased through *Tappi,* 122 E. 42nd Street, New York 17, N. Y.

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May we furnish full information to meet your requirements?

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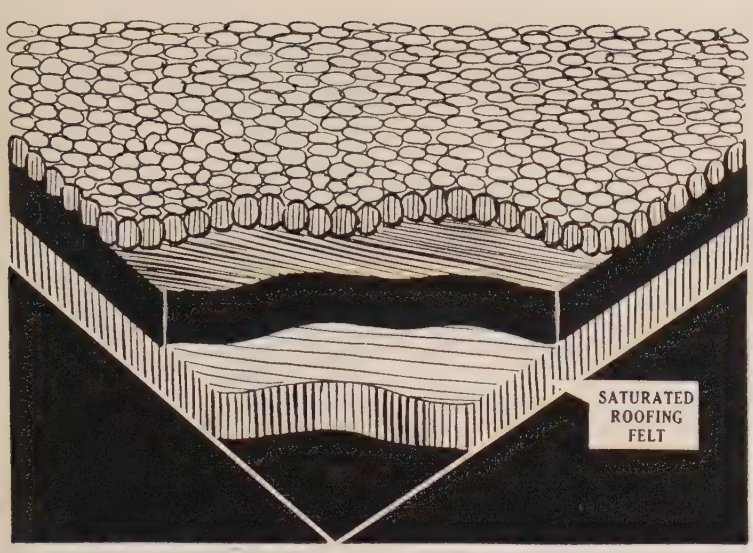


Saturating felts . . .

with high wood-pulp additions.

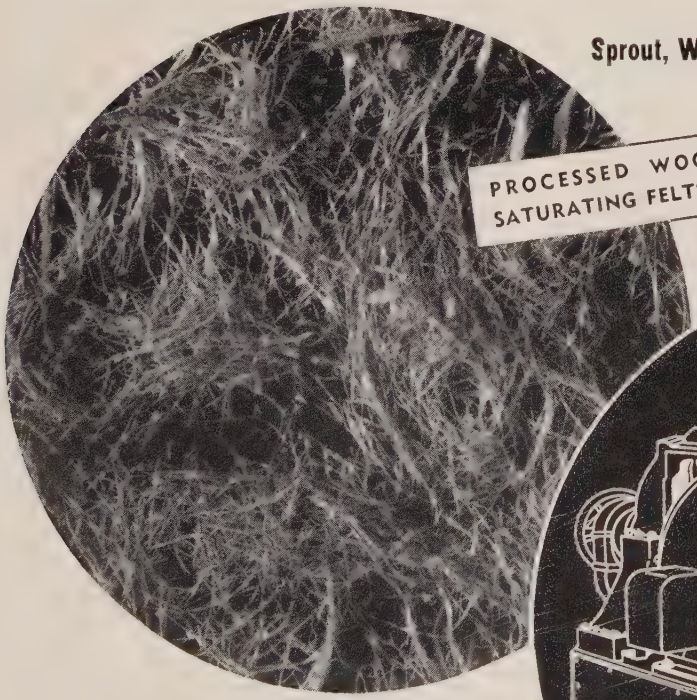
Because of lower manufacturing costs, modern dry felt producers are looking to wood pulp as a partial replacement for rags in the furnish.

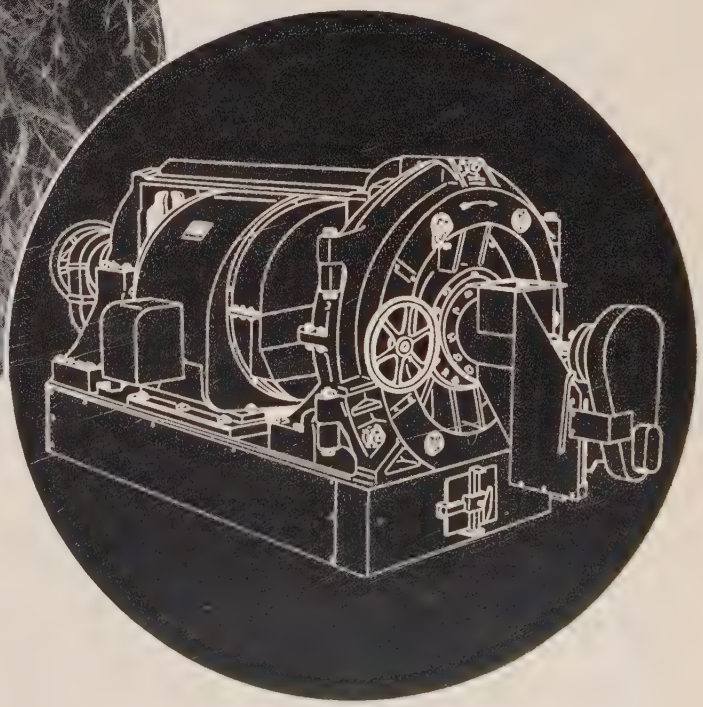
On this service, Sprout-Waldron Refiners are the natural complement to the preliminary attrition of the heat and chemically softened wood chips. They assure high tonnages and discharge the pulp as slender fibers without degradation.

In felt production, S-W Refining improves quality and uniformity of saturation. Excellent folding properties are maintained.

Let us consult with you on your problem.

Sprout, Waldron & Co., Inc., 38 Waldron St., Muncy, Pa.





SPROUT WALDRON
Manufacturing Engineers
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45

(*Continued from page 62 A*)

Industrial Hygiene and Toxocology, Vol. I. Prepared by a group of specialists under the editorship of Frank A. Patty, Director, Industrial Hygiene Service, General Motors Corp., Interscience Publishers, New York. 1948. Cloth, $6^1/_2 \times 10$, 531 pages. $10.

Eleven contributors to this book covered such subjects as industrial hygiene records, survey of personnel, fatigue, environmental factors, mode of entry and action of toxic materials, sampling and analysis of atmospheric contaminants, radiant energy, ventilation, dermatoses, occupational diseases, fire and explosion hazards, dust, and respiratory protective devices. Since more and more companies are installing plant first-aid departments there should be considerable interest in a book such as this that deals primarily with hygiene experience in a number of industries.

Copies may be obtained through *Tappi*.

Aquametry. By John Mitchell, Jr. and Donald M. Smith, Ammonia Dept., E. I. duPont deNemours, Inc., Interscience Publishers, New York. 1948. Cloth, 6×9, 460 pages, 51 illustrations, 143 tables. $8.

Aquametry is a generic term proposed for all analytical procedures used in the measurement of water. The principal objective of this book is to make available to chemists the various analytical uses of the Karl Fischer reagent. The procedures described cover the determination of water in various organic compounds, organic carboxylic acid, anhydrides, amines and nitriles, peroxides, etc. The book is remarkably well documented and should be of great value to analytical chemists doing complex determinations in organic chemistry.

Copies may be obtained through *Tappi*.

Instrumental Methods of Analysis. By H. H. Willard, Univ. of Michigan, L. L. Merritt, Jr., Indiana Univ., and John A. Dean, Univ. of Alabama. D. Van Nostrand Co. Inc., New York. Paper cover, $8^1/_2 \times 11$, 247 pages, photo-offset. $4.

The 17 chapters in this manual are the outgrowth of lectures given by the authors on the use of instrumental or physico-chemical methods of analysis. The chapters cover colorimeters, fluorescence meters, spectroscopy and flame photometer, X-Ray diffraction methods, radioactivity, thermal conductivity, the centrifuge, pH determinations, polarography, amperometric, conductometric and potentiometric titration methods. Although this book was prepared primarily for the benefit of instructing college students it is a useful manual for use in all chemical laboratories.

Copies may be purchased through *Tappi*.

High-Polymer Physics. A symposium edited by Howard A. Robinson, Manager, Physical Research, Armstrong Cork Co., and published under the auspices of the American Institute of Physics. Remsen Press Div., Chemical Publishing Co., Brooklyn, N. Y. 1948. Cloth $5^1/_2 \times 8^3/_4$, 572 pages. $12.

This book is made up of contributions by 39 individuals and covers four major fields. Determination of the molecular structure; Physical properties; Chemical physics; and Instrumentation of high polymers. The great majority of the contributers are connected with industrial research laboratories rather than colleges.

Copies may be obtained through *Tappi*.

EMPLOYMENT SERVICE

In the April issue of *Tappi* several listings of individuals seeking positions and of companies looking for men were published in this department. These requests appear but once unless the Editor of *Tappi* is advised prior to the 15th of any month to repeat them in the following month's issue.

Since its inception the Technical Association has acted as a clearing house on matters of employment. In this activity it has been eminently successful. A must in the daily routine of the headquarters office is to get an unemployed member back in a job. Although very few of the applications included in the Positions Wanted column of the April issue of *Tappi* related to unemployed members they indicated a desire for change, self-improvement, etc.

Generally, the central office is able to take care of employment matters much more quickly than this magazine. However, the publication of these requests have the merit of reaching individuals and companies that may not have solicited the services of the Association relative to employment.

Individuals and companies desiring to use this service should prepare their requests in the form they wish to have them appear in this department. In addition the Association should be furnished with complete details so that it may render effective service.

Responses to inquiries should be addressed to this magazine and to the code numbers indicated.

Position Wanted

E17-49 Scandinavian plant manager, 40, trained as chemist, experienced in wallboard, kraft pulp and paper, including design and construction desires position with an American firm. Now located in Finland.

E18-49 Chemical engineer now technical director desires position in sales service in Canada. More than ten years experience in the processing of kraft, sulphite and groundwood papers.

E19-49 Chemist for paperboard mill. Development and control work. 1942 graduate chemical engineer.

E20-49 Chemist or chemical engineer. Five years experience in paper conversion plant, specializing in plastic and synthetic coatings. Knowledge of adhesives, paper, waxes, coatings and equipment. Three years organic laboratory. Desires mill control or research work.

E21-49 German papermaker licensed to emigrate to America. 25 years experience in all major grades. Paper school certificate from Altenburg and Oldenburg Universities. Married. Will accept any kind of papermill employment at start. Will provide own passage to America. Needs employment promise to emigrate.

Position Open

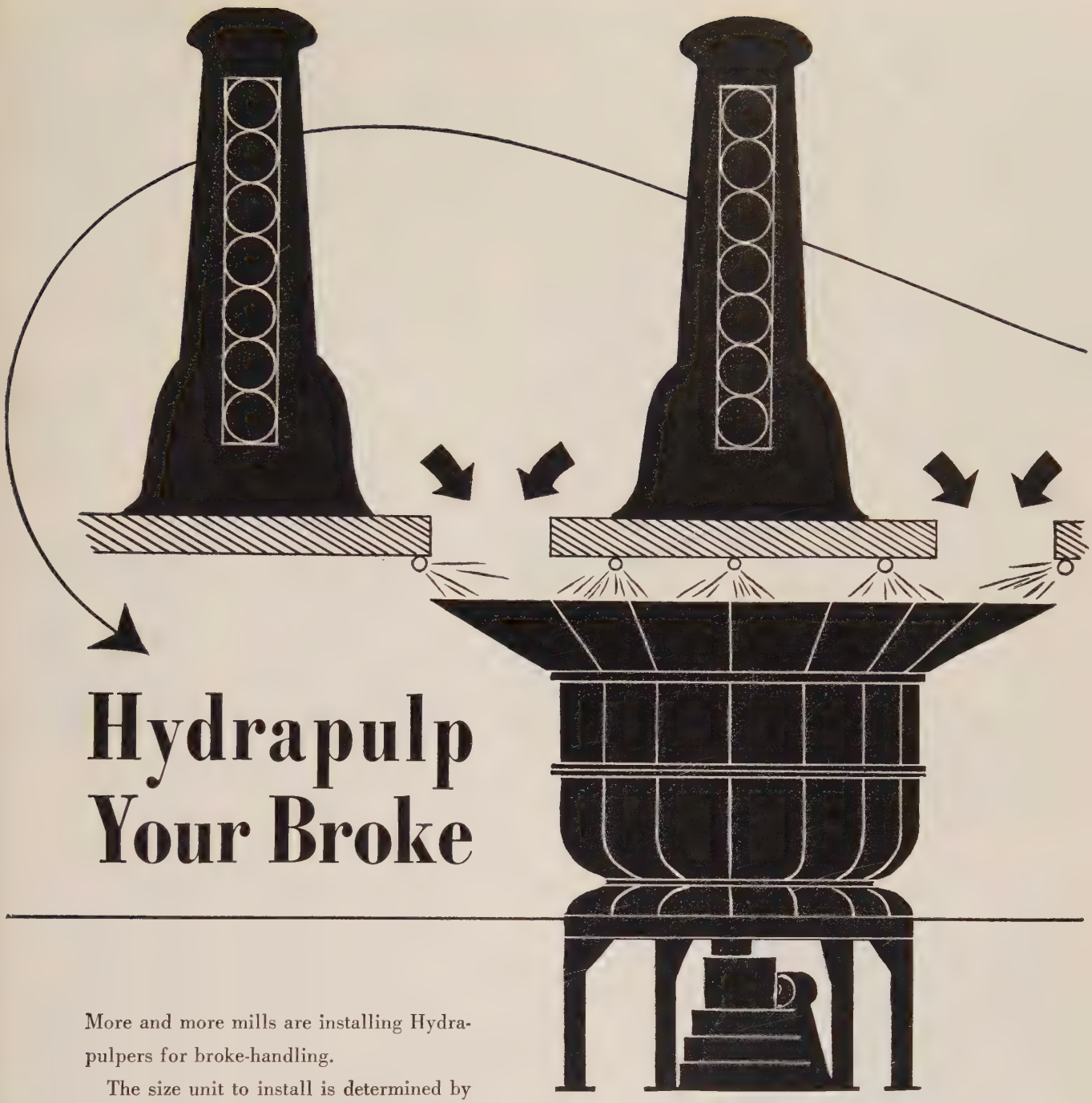
P7-49 Graduate engineer for development work on corrugated containers and container testing at large corrugated box plant in the Southeast. Several years experience in design, evaluation, and manufacture of corrugated containers required.

YES — GO WEST!

Portland, Ore.
September 12–15, 1949

THEN — GO EAST!

Boston, Mass.
Fourth Engineering Conference
October 31–November 3, 1949



Hydrapulp Your Broke

More and more mills are installing Hydrapulpers for broke-handling.

The size unit to install is determined by dividing the production of the machine by four and choosing a size capable of slushing that amount of stock in an hour—in other words, fifteen minutes' production.

As a rule, the best location is under the calenders and winder where broke from the dry end dryers and entire finishing end can be dropped to the tub as fast as produced.

Broke Hydrapulper speeds vary—slower when slushing the normal machine trim, faster when a break occurs.

This variable speed arrangement and other special features of broke Hydrapulpers gladly explained.

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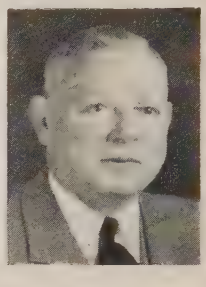
Associate: ALEXANDER FLECK LIMITED, OTTAWA, CANADA

Everything's all set for THE WOODS TRIP

The Weyerhaeuser Timber Company at Longview, Washington, as in 1934, will again play hosts to the woods trip of the Fall Meeting of TAPPI. Buses will leave the Multnomah Hotel in Portland for a comfortable, leisurely trip through scenic country to Longview, where the workers' train will be waiting for the tourists on Weyerhaeuser tracks and will take off promptly with coaches and special observation cars. The train will travel to the headquarters camp through settled areas and farm lands, moving on to one of the woods operating camps high in the Cascades where loggers are living permanently and where the actual operations of logging, falling, bucking, hauling are going full blast. Lunch will be served at the logging camp. Visitors will be back in Portland by dinner time.

Howard W. Morgan
Manager, Pulp Division
Weyerhaeuser Timber Company

Clyde A. Corman
Logging Manager
Weyerhaeuser Timber Company



Harry E. Morgan
Manager
Longview Branch
Weyerhaeuser Timber Company

MEET YOUR HOSTS FOR THE DAY

Up in the Paul Bunyan country of he-men and big trees, sprawls the huge and varied operations of the Weyerhaeuser Timber Company.

Here, where the Columbia River takes its last big bend toward the Sea, is represented an integrated forest products industry whose manufacturing units at Longview alone cover over 600 acres.

Here are large sawmills, a sulfite pulp mill and a new kraft pulp mill, a new chemical recovery plant, a plywood plant, a bark products plant, two big log and one small wood hydraulic barking plants and a forest products laboratory.

These are all working together efficiently for the ever greater utilization of the trees grown on Weyerhaeuser land.

During your trip to Weyerhaeuser, you will see a forest exhibit displaying the different species of wood that are used in the manufacture of pulp and paper, as well as one showing the different grades of pulp manufactured.

Get Abo-o-ard That Train! Omen of good times to come in 1949 is in the wide grins on faces of these members of the 1934 woods trip to Weyerhaeuser at Longview.

yes . . .

GO WEST!

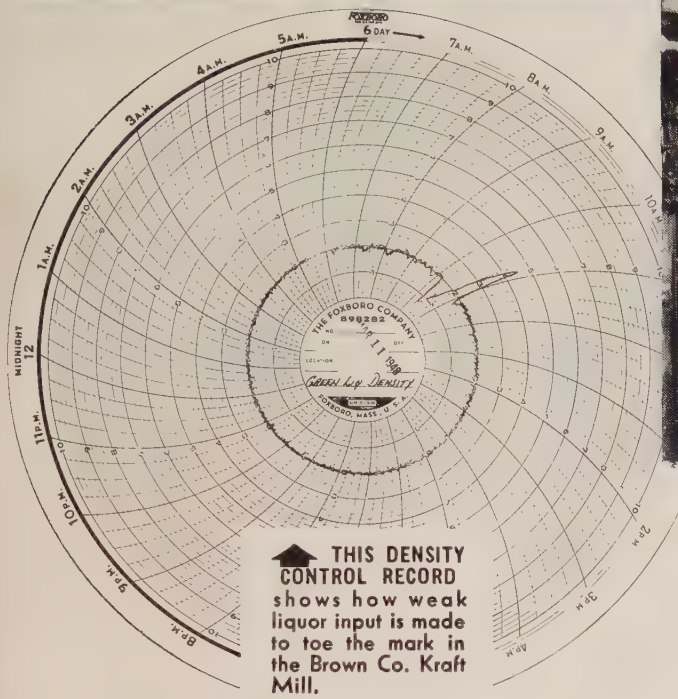
. . . for the Fall Meeting of

TAPPI

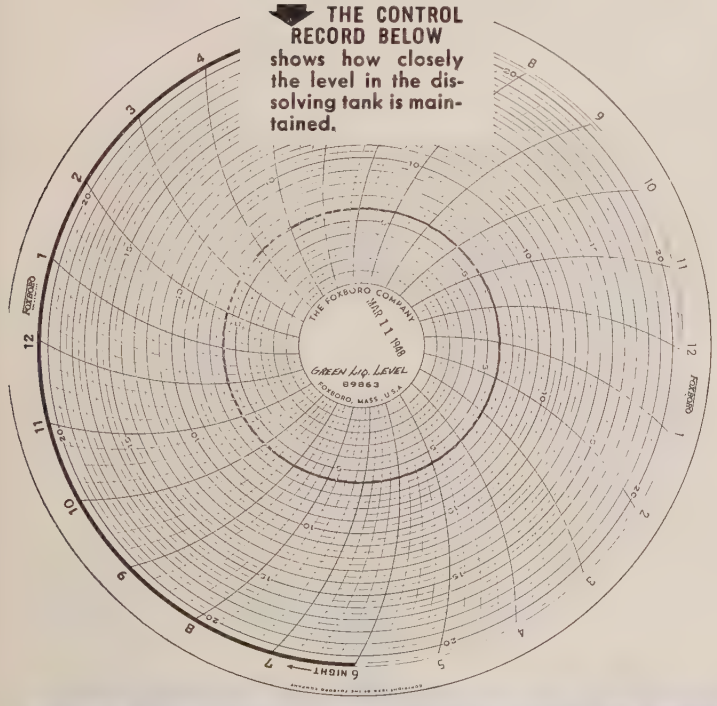
September 12-15

Multnomah Hotel, Portland, Ore.

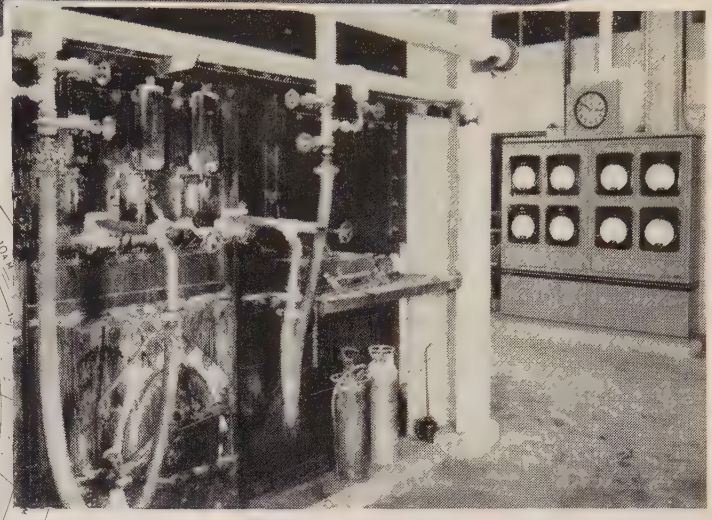
Here's *Automatic* dissolving tank control that completely tames tough variables



THIS DENSITY CONTROL RECORD shows how weak liquor input is made to toe the mark in the Brown Co. Kraft Mill.



THE CONTROL RECORD BELOW shows how closely the level in the dissolving tank is maintained.



At the Brown Co.'s new Kraft Mill in Berlin, N. H., Baumé and level of the dissolving tank are controlled by two of the instruments on the recovery furnace control cabinet shown above.

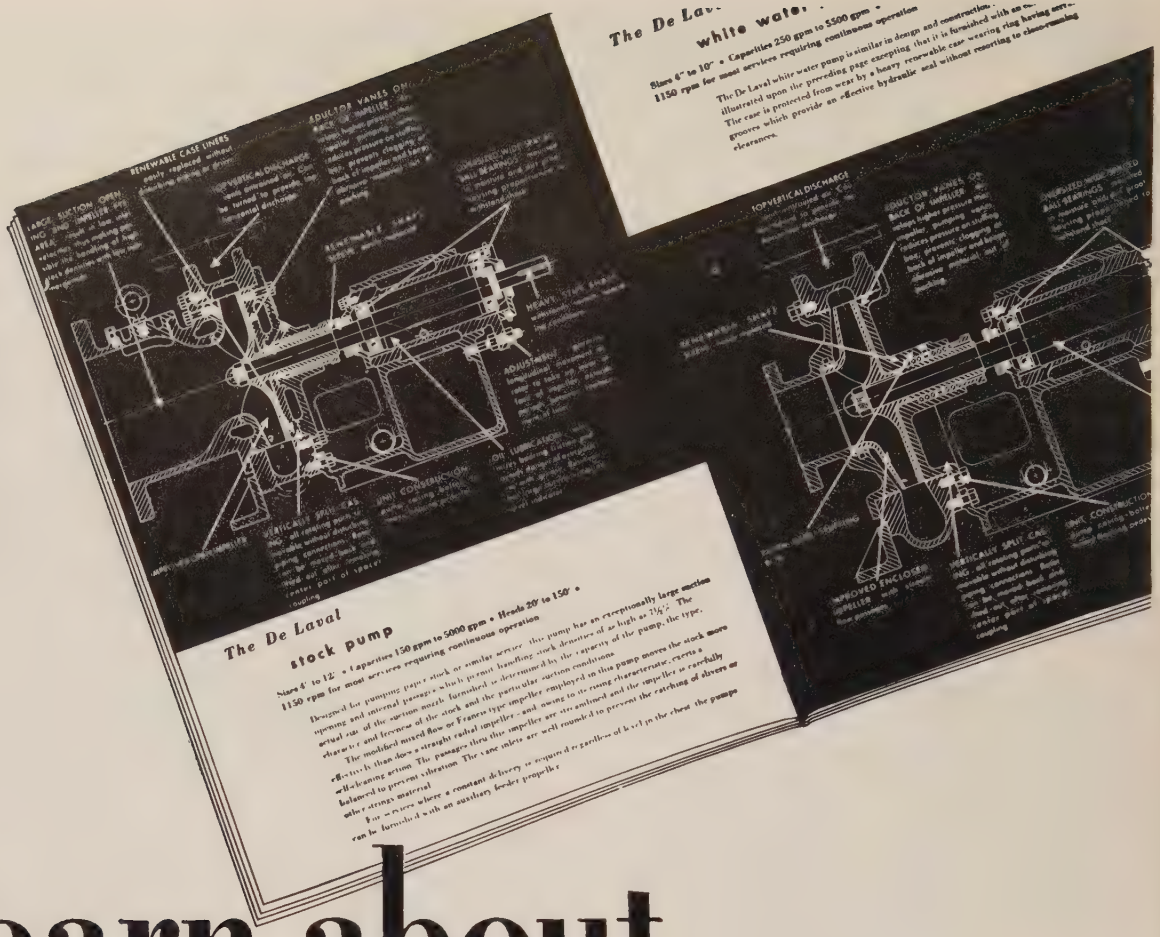
Foxboro Automatic Dissolving Tank Control is a simple, practically fool-proof system that pays off in two ways: (1) it provides continuous draw-off of uniform quality raw green liquor to the recausticising plant and (2) saves valuable time consumed in manual, batch operation. Its accuracy is demonstrated by the typical chart records reproduced at the left.

Such accuracy in dissolving tank control is not produced by an ordinary application of ordinary instruments. It calls for the unique advantages of Foxboro Model 40 Controllers plus the ingenuity of engineers intimately acquainted with pulp and paper processing.

With the development of this integrated, accurate control system, the pulp and paper industry advances another step closer to completely-automatic processing and all its production advantages. Many of the steps toward this objective have been taken with the help of just such Foxboro developments as this. Why not discuss its features with a Foxboro pulp and paper mill engineer? Write **The Foxboro Company, 78 Neponset Avenue, Foxboro, Mass., U. S. A.**

FOXBORO Engineered CONTROL

REG. U. S. PAT. OFF.



learn about

the latest improvements in paper mill pumps

Send for your copy of this new De Laval pulp and paper mill pump catalog and get all the facts about the new line of De Laval pumps especially designed for handling paper stock, white water, liquors, clays and fillers.

As a practical, paper mill man you'll appreciate the many exceptional features of these new pumps.

For example:

- The stock pumps are designed for handling extremely high densities.
- Renewable liners protect surfaces subject to wear or corrosion.
- Shafts, sleeves, bearings and other parts are interchangeable.
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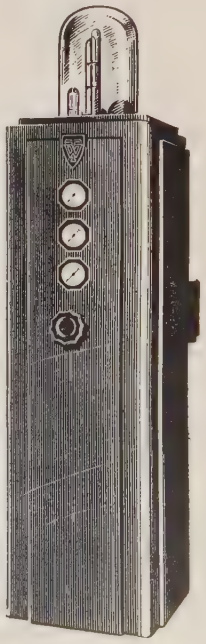
2

CHLORINATION KEEPS SLIME OFF YOUR PAYROLL

Of course slime doesn't actually stand in the monthly payroll line, but nevertheless it *does* cost you money just as effectively — for example, off-quality breaks, stock losses and screen plugging.

To reduce these losses on your cost sheet, use a method already proven by performance in scores of paper mills throughout the country — Break-Point Chlorination, engineered by Wallace & Tiernan.

Applied to your fresh-water supply after a careful survey by Wallace & Tiernan Engineers, this method controls slime by destroying its major cause—bacteria. Moreover, Break-Point Chlorination used in conjunction with chloramines or other corrective chemicals for stock or white water treatment, can ensure production of a sterile paper or board—a factor of prime importance in food and dairy packaging.



Write today to learn how these advantages of Break-Point Chlorination—backed by Wallace & Tiernan's 35 years' experience in water purification—can go to work for your mill.

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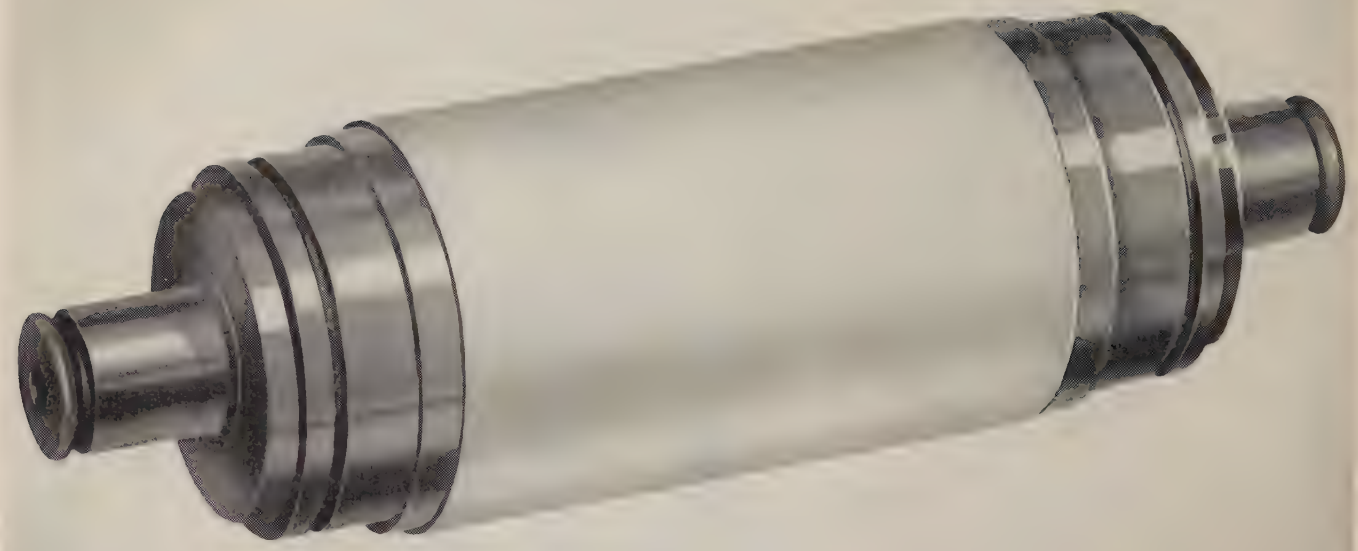

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Calendar of TAPPI Meetings

NATIONAL

General Fall Meeting, Multnomah Hotel, Portland, Ore., September 11–15, 1949.

Fourth Engineering Conference of the Pulp and Paper Industry, Statler Hotel, Boston, Mass., October 31, November 1–3, 1949.

LOCAL SECTIONS

Delaware Valley Section: Engineers Club, Philadelphia, May 26, 1949—"Long Range View of the Pulp Supply," by James L. Ritchie, U. S. Pulp Producers Association.

Empire State Section: The Sagamore, Bolton Landing, Lake George, N. Y.
June 2–4, 1949—Annual meeting.

Maine-New Hampshire Section:
June 17–18, 1949, Spring meeting at the Wentworth-by-the-Sea, Portmouth, N. H.

Paper and Packaging Specifications

FEDERAL SPECIFICATIONS

UU-C-76b (Amend. 1, Jan. 24, 1949) Cards; Guide, Card-Size.

UU-P-21a (Amend. 1, Dec. 23, 1948) Pads; Memorandum.

UU-P-121d (Amend. 1, Nov. 9, 1948) Paper; Bond, White and Colored.

UU-P-134 (Feb. 7, 1949) Paper; Bread-Wrapping, Waxed, Self-Sealing.

Note: This specification covers self-sealing paper for use in breadwrapping machines.

The paper specified is free from unbleached or groundwood pulp and is waxed with fully refined paraffin wax. The other requirements include basis weight of the dewaxed paper; content of wax, including amount that must be on the surface of the paper, melting point of wax; bursting strength and tearing resistance. The testing procedures for the wax requirements are contained in the specification. Reference is made to the Federal Specification UU-P-31, Paper; General Specifications, for the descriptions of the other testing methods required.

The specification is a product of the Federal Specifications Board Technical Committee on Paper and Paper Products, B. W. Scribner, National Bureau of Standards, Chairman. It was developed with the assistance of the Waxed Paper Institute (U.S.A.). Copies may be obtained from the Superintendent of Documents, Government Printing Office, Washington 25, D. C., price 5 cents.

UU-P-185a (Amend. 1, Jan. 24, 1949) Paper; Computing Machine.

UUP-231 (Amend. 1, Dec. 23, 1948) Paper; Duplicator, Liquid Process.

UU-P-322 (Dec. 9, 1948) Paper; Machine-Shorthand.

Note: This is the first specification to be issued in the new form adopted by the Federal Specifications Board ($8\times10^{1}/_{2}$ for 3-ring binder). The paper mentioned in this specification is a half-tone news having a hard smooth finish and containing not more than 70% groundwood pulp. The physical requirements comprise weight, thickness, tensile strength, and brightness.

UU-P-328b (Amend. 1, Jan. 24, 1949) Paper; Manifold.

UU-P-523 (Amend. 1, Dec. 23, 1948) Paper; Sanitary Tissue.

UU-T-101c (Sept. 23, 1948) Tape, Gummed; Mending, Reinforcing, and Securing (Paper, Cellulose, and Cloth).

U. S. ARMY SPECIFICATIONS

Office of the Chief of Ordnance

UN-T-106 (May 24, 1948) Tape, Masking; Paper, Pressure-Sensitive.

Note: This specification replaces AXS-1260.

LLL-B-631b (Amend. 1, Jan. 14, 1948) Boxes; Fiber, Corrugated (for domestic shipment).

Note: This supercedes AXS 1729.

LLB-636b (Amend. 1, Jan. 14, 1948) Boxes; Fiber, Solid (for domestic shipment).

Note: This supercedes AXS-1727.

JOINT ARMY-NAVY SPECIFICATIONS

JAN-P-131 (Amend. 2, Oct. 7, 1948) Barrier-Material; Moisture-Vaporproof, Flexible.

Note: This supercedes Amend. 1, March 16, 1945 (Army No. 100-35, Navy No. 39P16b Section XXXI).

JAN-P-224 (Amend. 1, Oct. 31, 1947) Paper (Foiling).

Note: (Army No. 50-11-24c, Navy No. 53P33).

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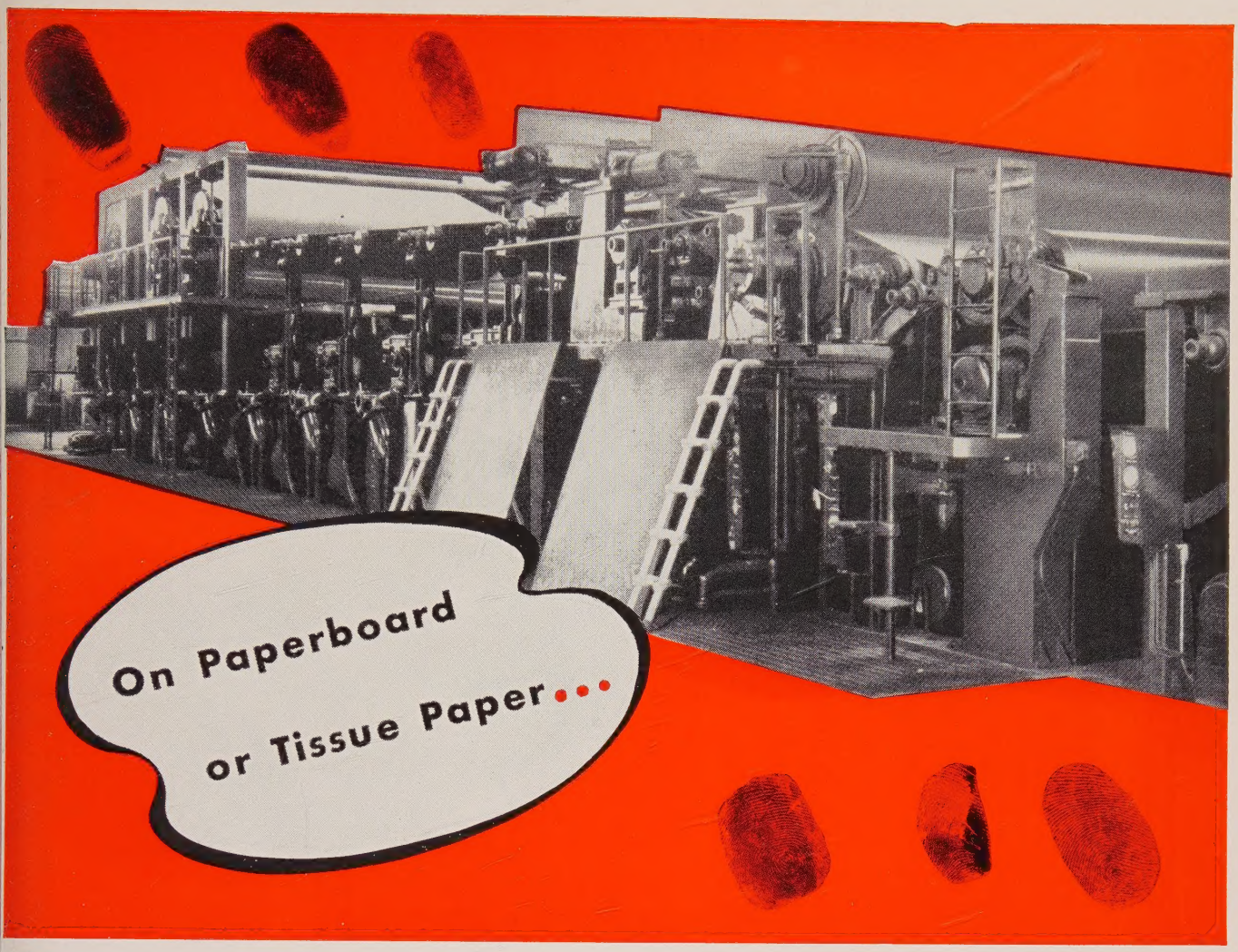

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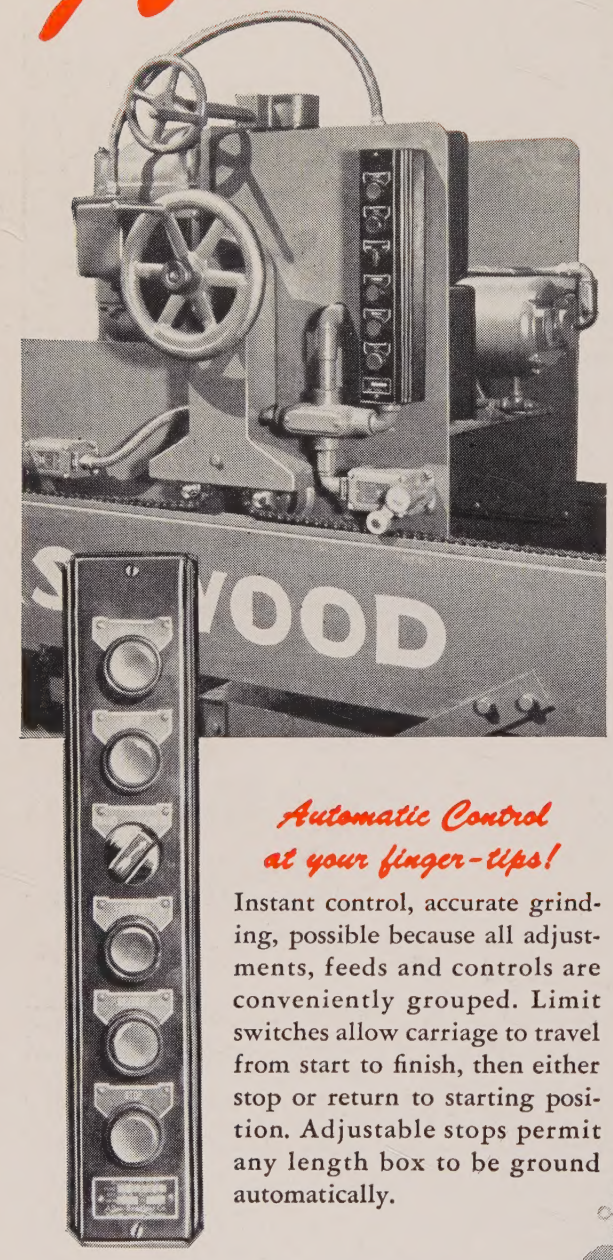

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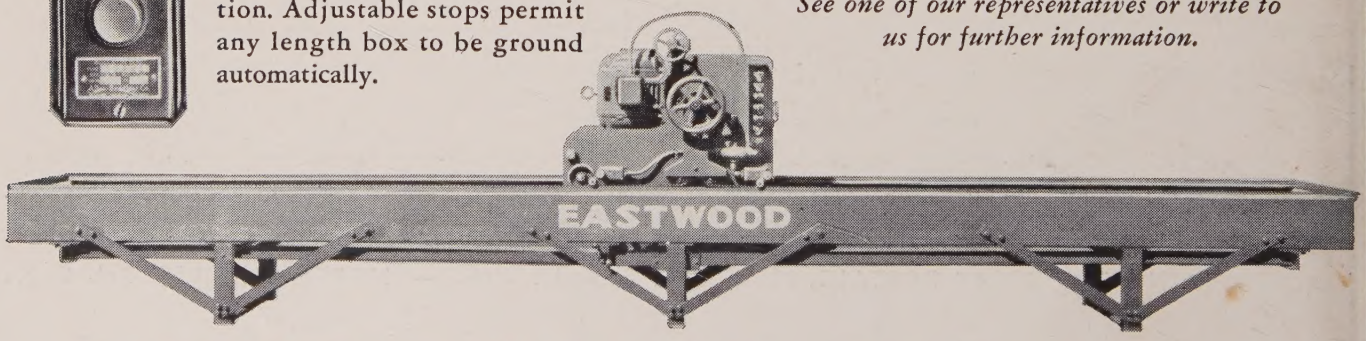

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